BUILDING ENERGY SIMULATION

User News

Volume 19 ¨ Number 4 ¨ Winter 1998

For Users of DOE-2, SPARK, BLAST and their Derivatives

What's New ?

¨ **Status of EnergyPlus ...**

I want to test the alpha version, how do I get it? ¼ How will it work? ¼ How can I develop an interface to EnergyPlus? ...

To learn the answer to these and other EnergyPlus questions, come to an update workshop in Chicago on Saturday afternoon, 23 January 1999 (just prior to the IBPSA-USA and ASHRAE Winter meetings). Detailed information is on the EnergyPlus web site:

http://www.eren.doe.gov/buildings/energy_tools/EnergyPlus.htm.

If you are an **interface or module developer** who wants to use EnergyPlus, please contact Dru Crawley (Drury.Crawley@hq.doe.gov). There will also be a developer meeting specifically for those interested in creating a user interface or developing new simulation modules for EnergyPlus. [Note: to participate in the developer meeting, you must have already executed a developers license for EnergyPlus.]

¨ **DOE-2.2 Release Postponed ...**

The release of DOE-2.2, which was announced for July/August of this year in the Summer '98 issue of the *User News,* has been postponed until a cross license agreement between LBNL and program co-author, Hirsch & Associates, can be finalized.

¨ **SRG Website ...**

We are working on a new, permanent website for the Simulation Research Group. In the meantime, please visit the Building Technologies Department site at LBNL (http://eetd.lbl.gov/btp/) and follow the links to the Simulation Research Group.

What's New? is continued on p. 19

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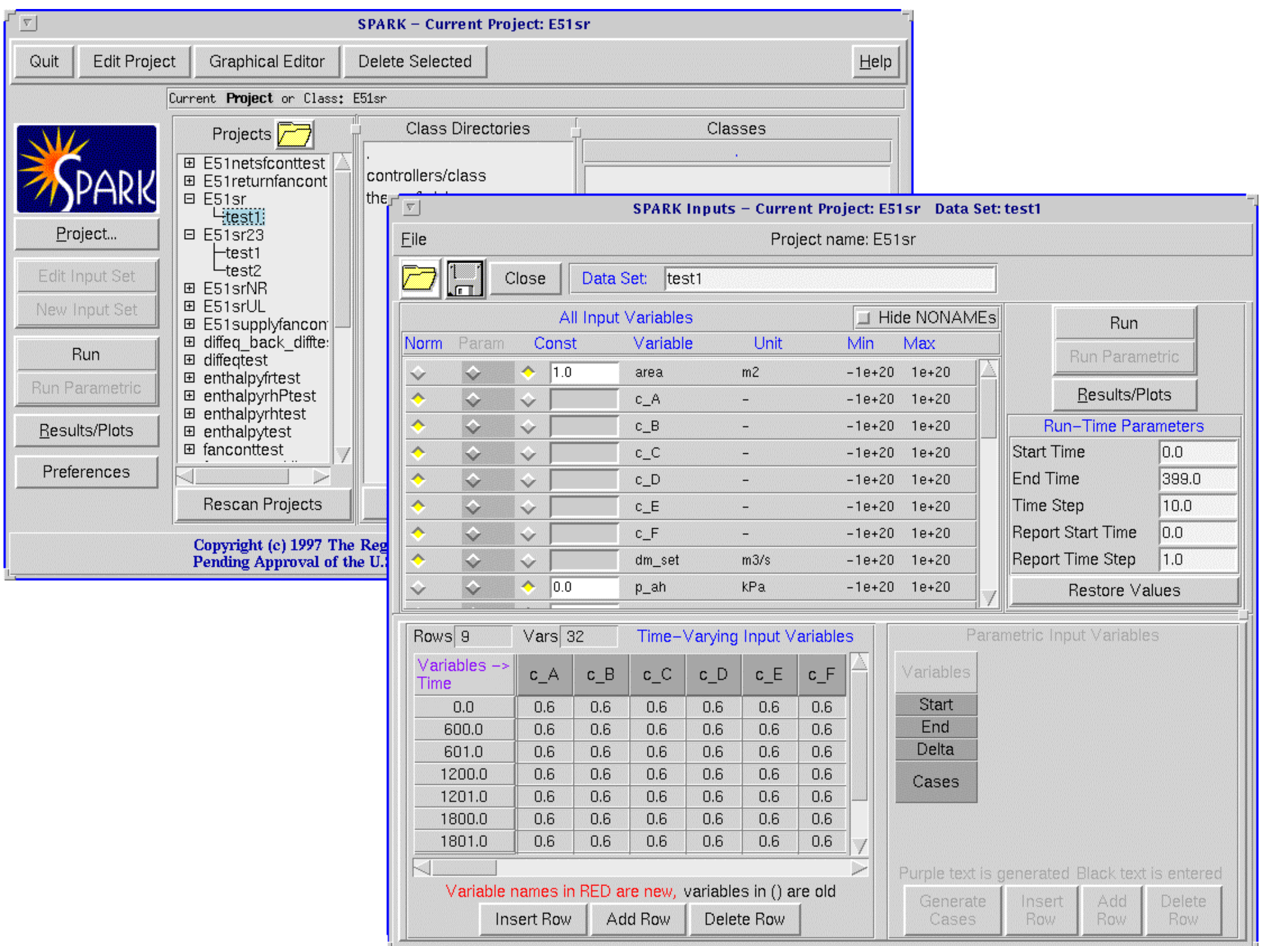
The *Building Energy Simulation User News* is published by the Simulation Research Group at Lawrence Berkeley National Laboratory with cooperation from the Building Systems Laboratory at the University of Illinois. Direct comments or submissions to Kathy Ellington, MS: 90-3147, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, or email kathy@srge.lbl.gov or fax us at (510) 486-4089. Direct BLAST-related inquiries to the Building Systems Laboratory, phone (217) 333-3977 or email support@blast.bso.uiuc.edu ☺ ☺ ☺ ☺ 12/98 2000

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology, State and Community Programs, Office of Building Systems of the U.S. Department of Energy, under Contract No. DE-AC03-76SF00098. Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, University of California, Berkeley, CA 94720 USA ¦

Call for VisualSPARK Beta Testers

VisualSPARK is now available for beta-testing. *VisualSPARK* runs under both UNIX and Windows™ 95/98/NT. It has a different user interface than WinSPARK (which also runs under Windows and has already been beta tested and will soon be released -- see *User News*, Vol. 19, No. 2).

VisualSPARK allows you to build models of complex physical processes by connecting calculation objects. It is aimed at simulation of innovative and/or complex building systems that are beyond the scope of programs like DOE-2 and BLAST. The main elements of *VisualSPARK* are a *user interface, a network specification language,* an interactive *graphical editor,** an *object library* containing calculation modules for building components, a *solver* for solving the set of simultaneous algebraic and differential equations that correspond to the physical problem being simulated, and a *results display processor* for graphically plotting results. With the network specification language or the graphical editor you link the calculation objects into networks that represent a building's envelope and HVAC systems. *VisualSPARK* was developed by the LBNL Simulation Research Group and Ayres Sowell Associates, with the support from the U.S. Department of Energy.



Sample *VisualSPARK* input screens. In the front screen you assign values to input variables.

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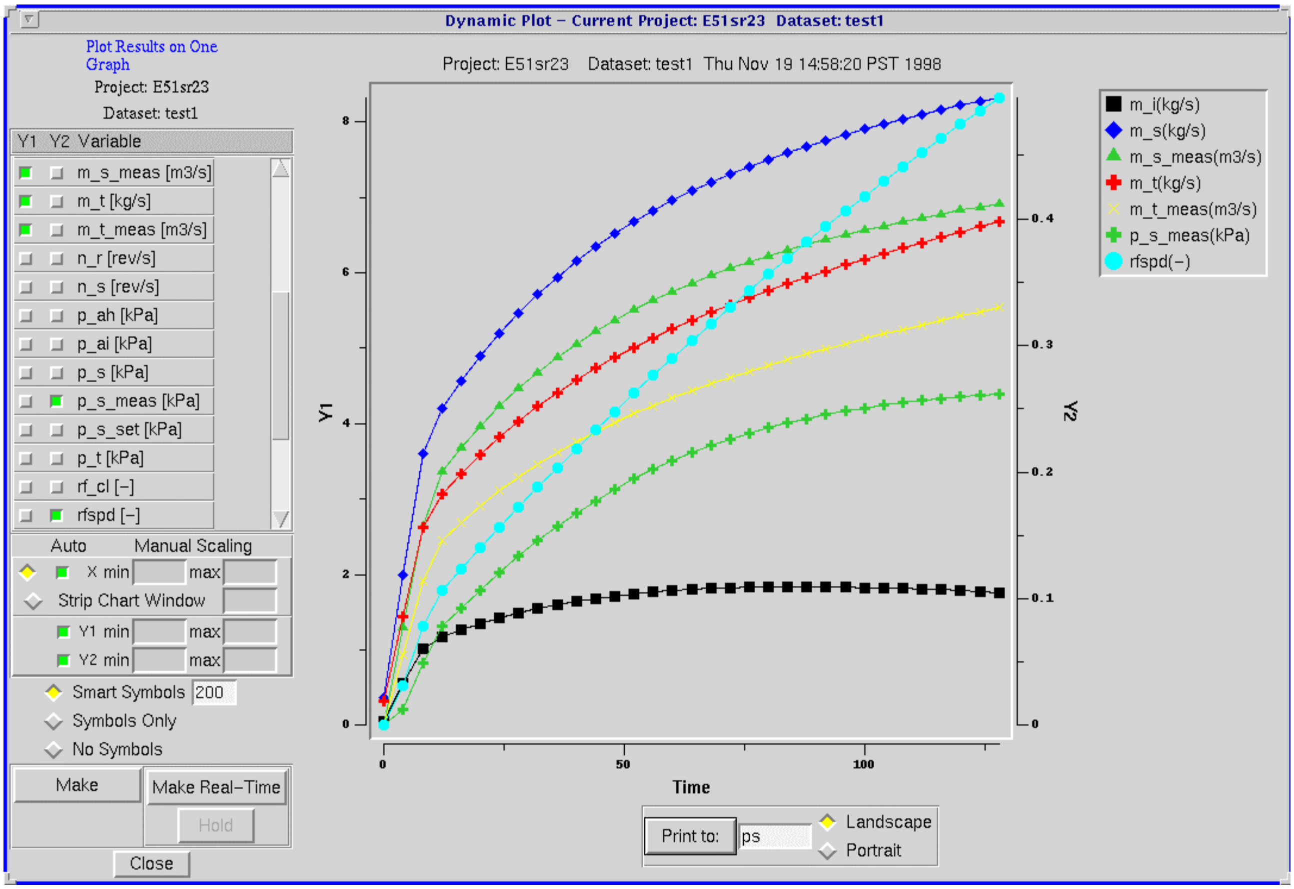
* Not available in the initial beta release of *VisualSPARK.*

VisualSPARK differs from programs like BLAST and DOE-2 in several important respects: (1) its time step can be as small or large as you want consistent with the dynamics of the problem being simulated; (2) it uses an iterative solution and so can easily handle non-linear systems; (3) it is equation based and so can simulate arbitrarily complex systems that can be described by sets of algebraic and differential equations; and (4) its algorithms are not hard wired, which means you can customize it to particular simulation problems. To help you get started, *VisualSPARK* comes with an object library of basic HVAC components like fans, mixing boxes, heat exchangers, coils, chillers, cooling towers and controls that you can assemble into complete HVAC systems.

Sample windows from the *VisualSPARK* user interface are shown here. For more information on the program you can download the *SPARK Users Manual* from www.ecs.fullerton.edu/~sowell/.



Example plot of *VisualSPARK* calculation results. There are several plotting options, including real-time plots that are displayed and updated as the simulation is running.

To run the UNIX version of *VisualSPARK*, you will need a computer running the SunOS, Solaris or Linux 86 operating system. To run the PC version of *VisualSPARK*,you will need a computer running the Windows 95, 98 or NT operating system. Both versions require a minimum of 30MB of disk space.

If you would like to be a *VisualSPARK* beta tester please contact Kathy Ellington at kathy@srge.lbl.gov. Specify whether you are interested in the UNIX or Windows version.

Using DOE-2 to Estimate Component Heating and Cooling Loads of the Entire U.S. Building Stock

by
Joe Huang
Simulation Research Group
Lawrence Berkeley National Laboratory

A recently completed project for the U.S. Department of Energy's (DOE) Office of Building Equipment combined DOE-2 results for a large set of prototypical commercial and residential buildings with data from the Energy Information Administration's (EIA) building energy surveys to estimate the total heating and cooling loads in U.S. buildings attributable to various building components such as windows, roofs, walls, etc. This information is useful for gauging the national conservation potentials for DOE's research in building energy efficiency.

The prototypical building descriptions and DOE-2 input files were developed from 1985 to 1992 to provide benchmark hourly building loads for the Gas Research Institute (GRI) and include 112 single-family, 66 multi-family, and 481 commercial building prototypes (Tables 1 and 2). The methodology used to develop these prototypes is described in three technical reports listed at the end of this summary that are available from GRI or LBNL. The DOE-2 input files for the commercial buildings have been put on the Simulation Research Group's ftp site at http://ftp.gundog.lbl.gov. The input files for the residential prototypes will be put on the web after they have been converted from a custom pre-processor procedure to standard DOE-2.1E macro language. Due to their size, the output hourly end-use loads files are on tape storage, but arrangements can be made to access them through ftp. Those interested should contact the author for information (YJHuang@lbl.gov).

Table 1. Prototypical Residential Buildings

Single-family Vintages		**Locations**		
A (pre-1940's)	A1 (retrofitted pre-1940's)	Boston	New York	Chicago
B (1950-1970's)	B1 (retrofitted 1950-1970's)	Minneapolis	Washington	Atlanta
C (1980's)		Miami	Fort Worth	Lake Charles
		Denver	Albuquerque	Phoenix Seattle
Multi-family Vintage/Size combinations (varies by region)		San Francisco	Los Angeles	Kansas City
small pre-1940	large pre-1940's			
small 1950-1959s	large 1960-1969s			
small 1960-1969s	large 1970-1979s			
small 1980s	large 1980s			

Table 2. Prototypical Commercial Buildings

Building Types		**Vintages**	
Large Office	Small Office	Old shell, Old system	Old shell, New system
Large Retail	Small Retail	New shell, New system	
Large Hotel	Small Hotel		
Sit-down Restaurant	Fast-foods Restaurant	**Locations**	
Hospital	Secondary School	Minneapolis	Chicago
Supermarket	Warehouse	Washington	Houston
		Los Angeles	

The DOE study consisted of two distinct tasks.

- The first was to do DOE-2 simulations of the prototypical buildings and develop methods to extract the building loads attributable to different parts of a building. For the commercial buildings, DOE-2 functions were written that corrected the LOADS loads for the actual zone temperature hour-by-hour and apportioned the corrected load to either heating or cooling depending on the building's load history. For the residential buildings, parametric simulations were used in which the heat flows through a building component were eliminated, and the resulting changes in building loads recorded.
- The second task was to estimate the number of buildings or floor area represented by each *prototypical*

building based on EIA's Commercial Building Energy Consumption Survey (CBECS) and Residential Energy Consumption Survey (RECS). These building stock data were then multiplied by the prototypical building component loads to derive aggregated totals by region, vintage, and building type.

This bottoms-up engineering approach produced estimates of 1.33 Quads of heating and 1.63 Quads of cooling energy use for 12 major building types representing three-quarters of the commercial building floor area, and 5.93 Quads of heating and 1.45 Quads of cooling for all U.S. residential buildings. Scaled to the entire commercial building stock, the heating energy use is quite close to EIA, but 40% lower than GRI estimates; the cooling energy use is 10-50% higher than EIA, but 20% lower than GRI estimates. The residential heating and cooling energy uses are both within 10% of EIA but are 20% higher for heating and 20% lower for cooling compared to GRI estimates.

The main objective of the study, however, was not to derive another estimate of national building energy use, but to provide insight into the *composition* of the building loads by type, vintage and building component. Figures 1 and 2 show the national heating and cooling loads for the residential and commercial building stock in the form of pie charts. The size of the heating and cooling pies are proportional to the load. Those building components with net heat losses are shown with stripes, while those with net heat gains are shown by cross-hatched pie slices. The contributing loads are shown on the upper half of each pie, which are partially offset by "free heat" or "free cooling" to the right of each pie. The remaining deficits are the net heating or cooling loads, which are shown as the exploded pie slices to the lower left. The enlarged slices show the heating and cooling energy use needed to meet the loads, which are substantially greater due to the inefficiencies of the system, plant, and electricity generation and transmission.

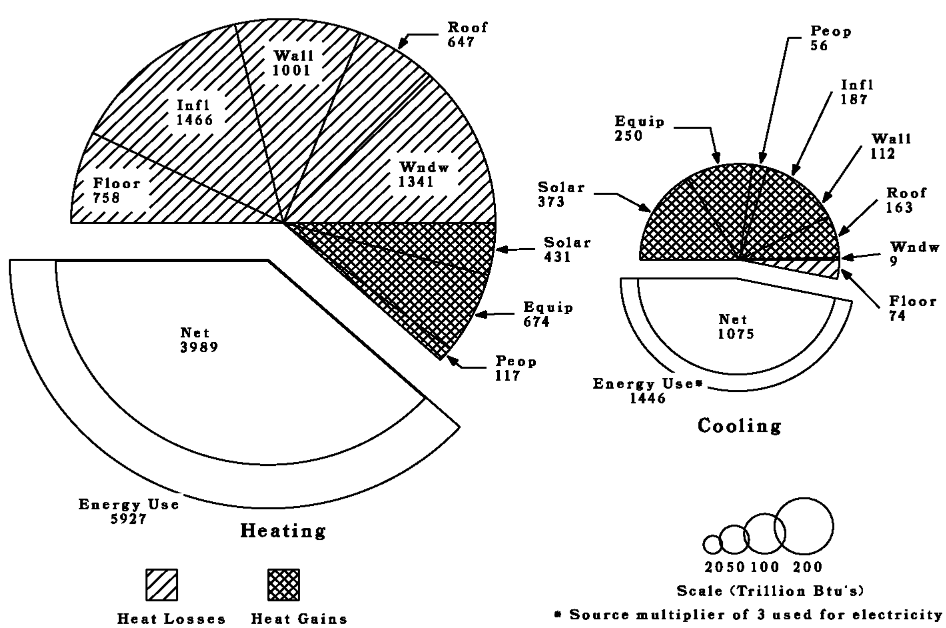


Figure 1: Aggregate Component Loads for all Residential Buildings (Trillion Btus)

Wall = wall heat flow
Roof = roof heat flow
Net = net heat flow
Solar = window solar heat gain
Floor = ground and floor heat flow
Peop = people heat gain
Infl = infiltration heat flow
Wndw = window conduction heat flow
Equip = equipment heat gain, incl. lights

References

Huang, Y.J. and Franconi, E.M., "Commercial Heating and Cooling Loads Component Analysis", LBL-33101, Lawrence Berkeley National Laboratory, Berkeley CA (1998).

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Huang, Y.J. and Franconi, E.M., "Commercial Heating and Cooling Loads Component Analysis", LBL-33101, Lawrence Berkeley National Laboratory, Berkeley CA (1998).

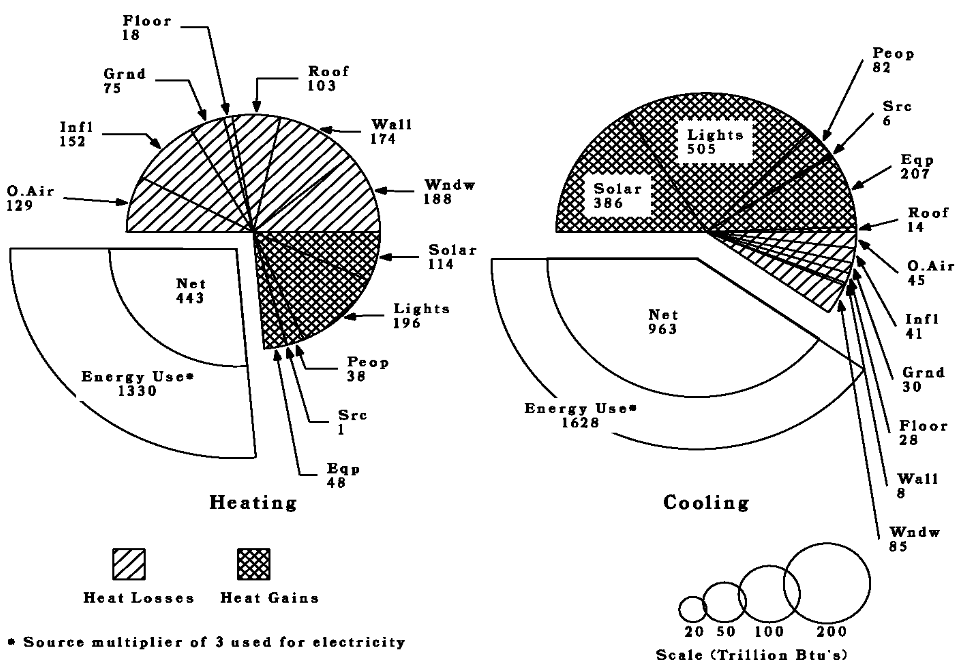

Figure 2: Aggregate Component Loads for all Commercial Buildings (Trillion Btus)

Wall = wall heat flow
Roof = roof heat flow
Net = net heat flow
Floor = floor heat flow

Solar = window solar heat gain
Floor = floor heat flow
Peop = people heat gain
Grnd = ground heat flow
O.Air = outside air heat flow

Infl = infiltration heat flow
Wndw = window conduction heat flow
Equip = equipment heat gain
Src = heat gain from non-electrical processes
Lights = lighting heat gain

CALIFORNIA ENERGY COMMISSION

Recent Report

This report is available from the Building Technologies Department at Lawrence Berkeley National Laboratory. Please fax your request to Kathy Ellington at (510) 486-4089

Report No.: RCDC/A.823/A532/1996

Energy Performances of Cooling Retrofits in Sacramento Public Housing

California Energy Commission
Sacramento, California

Summary
This project was a collaborative effort between the Sacramento Housing and Redevelopment Agency (SHRA), the Sacramento Municipal Utility District (SMUD), the California Energy Commission (CEC), Joe Huang & Associates (JHA), and Lawrence Berkeley National Laboratory (LBNL). The aim of the project was to use field monitoring and computer simulations to evaluate the energy savings and comfort improvements associated with three advanced cooling technologies:

- indirect-direct evaporative coolers (IDECs),
- ground-source heat pumps (GSHPs) and
- high-albedo roof coatings.

SMUD staff monitored interior conditions and cooling electricity consumption in recently renovated SHRA buildings during the summer and fall of 1994/95. Because SHRA encountered numerous problems with the evaporative cooler installations, SMUD also contributed 1993 monitored data from five evaporatively cooled houses to the analysis.

Developmental versions of the DOE-2 building energy simulation program were used to model the IDECs and GSHPs at the monitored sites. After the computer models were calibrated with the monitored data to the extent possible, they were used to compare the energy and comfort performances of these systems to those of standard air conditioners. The DOE-2 program was also used to estimate the energy savings and comfort improvements associated with high-albedo roof coatings, building orientation, energy-efficient windows, increased envelope insulation and weatherization. Lastly, the calibrated computer models were used to estimate the benefits of these cooling strategies in typical residential and light commercial buildings in other California locations.

COMIS

The Multizone Air Flow and Contaminant Transport Model for EnergyPlus*

by
Helmut E. Feustel and Brian V. Smith
Lawrence Berkeley National Laboratory

This article describes COMIS, a stand-alone, multizone, air flow and contaminant transport model that is being integrated into EnergyPlus. The PC-version of COMIS may be downloaded from http://www-epb.lbl.gov/comis/

Introduction
In order to provide good indoor air quality or to calculate a building's space-conditioning loads, it is important to know the air flow pattern within the building. Accurate air flow information is also necessary to correctly size space-conditioning equipment. **Figure 1** shows two fundamental approaches used to determine the air flow rate in buildings: measurement and mathematical modeling. Multiple tracer gases can be used to track air flows between the inside and the outside of a building as well as between interior zones. Tracer gas measurements give a value for air flows only under prevailing leakage and weather conditions; however, mathematical models can determine infiltration values for all leakage and weather combinations.

A number of air flow models have been developed to calculate air flow-related energy losses and flow distributions in single-zone and multizone buildings. Interzone air flow models can be divided into two main categories, single zone and multizone. Single-zone models assume that the entire building can be described by a single, well-mixed zone. These models are most often used for single-story, single-family houses with no internal partitions (e.g., all internal doors are open).

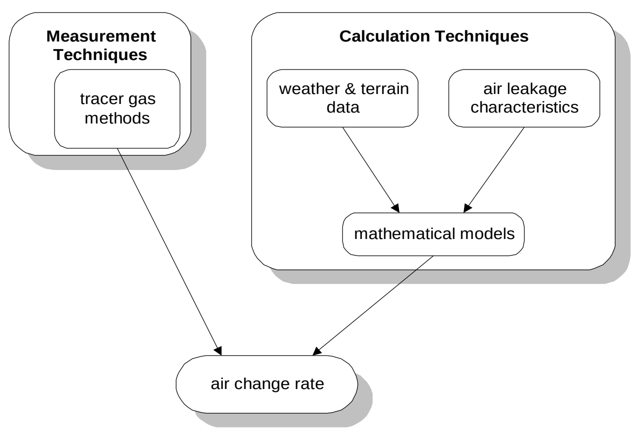

Figure 1: *Alternative Routes to the Estimation of Air Change Rates (Liddament 1986)*

Models for more complex Buildings
The principle underlying multizone models is that buildings are complicated interlacing grid systems of air flow paths (Fig. 2). Joints represent the zones of the building, and the connections between joints represent air flow paths. These paths include the flow resistances caused by open or closed doors and windows as well as air leakage through cracks in and around walls. The boundary conditions for the pressure distribution around the building can be described by grid points outside the building.

* Based on an article published in *Energy and Buildings (1998)*. The authors may be contacted at HEFeustel@lbl.gov or BVSmith@lbl.gov

Multizone infiltration network models deal with the complexity of flows in a building by recognizing the effects of internal flow restrictions. They require extensive information about flow characteristics and pressure distributions.

Because of the nonlinear dependence of air flow rate on pressure difference, the pressure distribution throughout a building can be calculated only by using an iterative method. Multizone network models have been developed to address simple structures of only a few zones or buildings having arbitrary floor plans, allowing for a number of zones limited only by the capacity of the computer being used for modeling. Models that deal with arbitrary building plans either use a large amount of computer memory or are equipped with very sophisticated mathematical routines to reduce their storage needs.

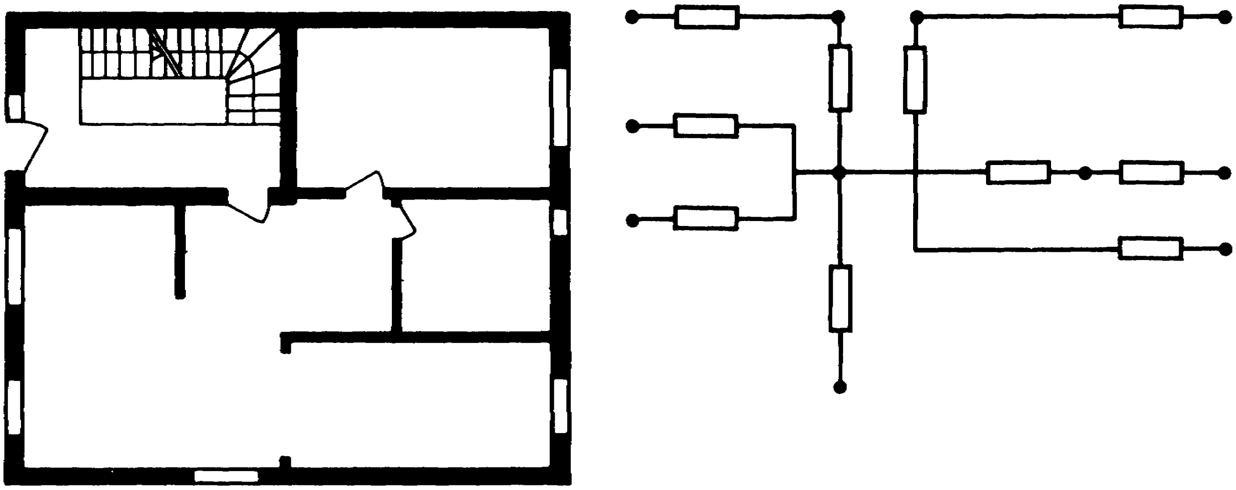

Figure 2: *Floor plan of a simple building and its representation in a two-dimensional nodal network (Feustel 1984)*

The COMIS Model

COMIS is a recent development in interzone air flow modeling. Because of its modular structure, COMIS has greater capability to simulate buildings than earlier multizone air flow models. COMIS can be used as a stand-alone model with input and output features or as an air flow module for thermal building simulation programs such as EnergyPlus.

COMIS grew from the work of an International Energy Agency's (IEA) expert group that began addressing multizone air flow modeling in 1990. The objective of this group was to study physical phenomena causing air flow and pollutant transport in multizone buildings and to develop modules to be integrated into a multizone air flow modeling system. Because it was developed by an international group of scientists under the aegis of the IEA, COMIS has the potential for immediate adoption in a number of countries and may therefore become a standard in multizone air flow modeling. So far, more than 200 copies of the program are being used in more than 15 countries.

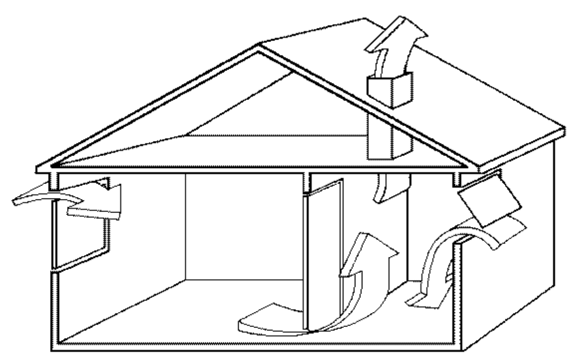

Figure 3: *Example of a simple multizone structure (Liddament 1986)*

Because partitions or inhomogeneous concentration in a building create multiple zones —areas of fully mixed volume with constant gas concentration and uniform pressure— multizone models are required to describe air flows. Multizone buildings can be single-room structures, single-family houses, or large building complexes. **Figure 3** shows an example of a very simple multizone building.

The air flows and distribution in a given building are caused by pressure differences resulting from wind, thermal buoyancy, mechanical ventilation systems or a combination of these (Fig. 4). Air flow is also influenced by the distribution of openings in a building's shell and by the building's interior pathways. Actions by building occupants can also lead to significant differences in pressure distribution inside a building. All of these influences on air flow patterns must be accounted for in an effective model.

COMIS Features

Crack Flow

Air flow through a crack is always a mixture of laminar, turbulent and transition flow. The proportion of each depends on the shape of the crack and the pressure difference across the crack. The power law equation is widely used to express the air flow characteristics of cracks:

$$Q = C_Q (\Delta P)^n.$$

This numerical representation shows that the air flow, Q, depends on the pressure difference, ΔP; however, this equation does not take into account the influence of the air properties and the air flow rate. Correction factors to account for these influences are described in *COMIS Fundamentals,* which details the underlying physical and mathematical basis of COMIS.

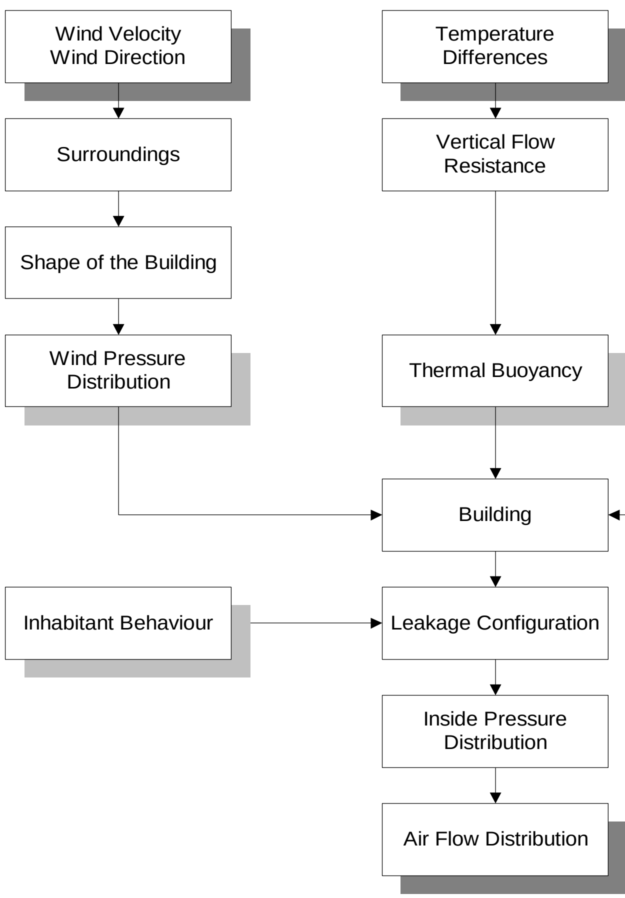

Figure 4: *Influences on the Air flow Distribution in Buildings (Feustel 1984)*

In air flow simulations, building components (e.g., windows, walls, closed doors) are often treated as single leakages. This has the advantage of reducing the input requirement, but reduces the accuracy of the simulation because the air flow is represented by only one set of boundary conditions (e.g., thermal gradients over the height of the component are neglected).

In the following we describe some calculational and input/output features of COMIS.

Flow Through Large Vertical Openings

Air flow through large openings (e.g., open doorways or open windows) is a main contributor to the transfer of air, pollutants and thermal energy between building zones or from the building to the outside. In most circumstances, thermal differences and/or differences in thermal gradients across a large opening will cause two-way flows. The prediction of air flows through large openings is difficult. Although good agreement exists in the literature regarding prediction of gravitational flows through large openings in steady-state conditions, large uncertainty remains regarding the definition of the discharge coefficient.

Air flow through large openings involves a number of different physical phenomena, including steady-state gravitational flows, fluctuating flows resulting from wind turbulence, and recirculation flows caused by boundary layer effects in a thermally-driven opening.

Ducts

Pressure losses through duct work are calculated based on friction losses described by Moody and dynamic losses resulting from flow disturbances caused by fittings that change the direction and/or area of air flow. Within the region of laminar flow (Reynolds number less than 2,000), the friction is a function of the Reynolds number only.

For turbulent flow (Reynolds numbers greater than 10,000), the friction factor depends on the Reynolds number, duct surface roughness and internal protuberances (such as joints) and is calculated by Colebrook's equation.

Fittings included in COMIS are entries, exits, transitions and junctions. The dimensionless coefficient, z , which has the same value in dynamically similar streams (i.e., streams with geometrically similar stretches, equal values of Reynolds number), has been obtained from engineering handbooks.

Passive Stacks

A passive stack forms a link from a building zone to the outside (roof) and includes the following elements:

- a round or rectangular duct,
- a grille or opening, visible in the room, mounted on the duct; and
- a cowl (hood) at the top of the duct outside.

Fans

Fans, a source of pressure differences, lift the pressure level between two zones. In COMIS, fans are described by polynomial fan curve provided by the user or approximated by COMIS from a set of volume flow/pressure data pairs.

Flow Controllers

Four types of flow controllers are distinguished; they represent most of the available dampers or regulators that respond to pressure drop or (duct) flow. The basic premise of controllers is that they have an opening through which the air flows. At higher pressures, a flap or valve may throttle the flow by gradually closing the opening.

Kitchen Hood

COMIS models kitchen hoods in different ways. Kitchen hoods can be either fan operated or stack operated. The hood itself can be simulated by means of a set of power law equations (i.e., by using the crack component) or by using a component that calculates the spread of pollutants into the zone.

User-Defined Air flow Components

COMIS allows you to define air flow components. The characteristics of these components need to be provided in terms of data pairs describing the flow/pressure relationship. With this information, air flow components that are not usually included in the program can be added.

Time Step

A time step is the period between events during a simulation. Simulations are performed for a time period defined by a start and stop time provided by the user. COMIS works with two different time steps: one for the air flow calculations and another for calculation of pollutant transport. As air flows are quasi-steady-state phenomena, the time step used for air flow calculations is based only on “external events,” which are schedules provided by the user. The time step is determined by the change of boundary conditions with time, i.e., weather data, opening configuration, fan schedule, etc. Pollutant transport and the related buildup or decay of contaminant concentrations are not steady-state physical phenomena. Therefore, the time step is calculated based on the shortest time constant of all zones within a building for a particular simulation configuration.

Zone Layers

A zone can be divided vertically into several sub-zones (layers). Layers allow for zones with more than one gradient for zone temperature and/or humidity (e.g., shafts, staircases). Layers may also be used to account for different sources or sinks in different heights of a zone. There is no limit to the number of layers that can be specified in a zone.

Schedules

A series of events for a particular parameter is described by a schedule. A schedule specifies the time of an event and the type of event. COMIS provides the following options for schedules:

- weather data (wind velocity, wind direction, air temperature, absolute humidity, barometric pressure),
- window schedule (window opening fraction),
- fan schedule (fan speed factor),
- zone temperature,
- absolute humidity,
- sink schedule (for up to five pollutants),
- source schedule (for up to five pollutants), and
- multi-schedule (for up to ten parameters with a common time step).

The time steps for all these schedules can be variable, ranging from one second to the length of the simulation period. Schedules can either be included in the COMIS input file or provided by separate schedule files. In the latter case, the COMIS input file only contains the names of the schedule files.

Contaminant Transport

Besides calculating air flow between zones, COMIS also calculates the transport and distribution of up to five contaminants. Simulation of contaminant transport in a multizone building leads to the definition of mass balance equations for each pollutant considered in each zone, based on the assumption that the pollutant concentration is well mixed in a zone and is transported from zone to zone by the flow of air. Although the air flow in buildings can be assumed to be steady state, contaminant transport is a dynamic effect. Therefore, it is critical to use a time step short enough to represent the dynamics. COMIS calculates the time step for contaminant transport as a function of the shortest time constant of all zones considered.

Output Options

COMIS provides a variety of output options. Besides the basic option, which provides air flow and pollutant transport data for each time step, data can be recorded or calculated in the form of tables. Calculations include the air change rates for individual zones and/or the whole building, mean age of air, the air change efficiency of the building and the room air change index. It is also possible to calculate and report mean values for the whole simulation period.

The ventilation heat loss energy, based on the incoming air temperature and the temperature difference between inside and outside of the building, is also calculated. For zones with temperature gradients, the temperature at the link is considered.

User Interface

Several interfaces were developed for COMIS. Here, we discuss two of them. *COMERL* offers an alphanumeric user interface that allows you to create or modify COMIS input files using a specific task-adapted editor. A database for air flow components (e.g., cracks, windows, HVAC components) is integrated into COMERL. The pre- and post-processor programs COMIN and COMOUT as well as COMIS itself can be run from within the shell.

IISiBât is the Intelligent Simulation Environment graphics interface adapted for COMIS. It provides a sophisticated graphical environment that runs on PCs or workstations and allows you to enter information in a straightforward way. IISiBât provides both inexperienced and advanced users with tools that can calculate the dynamics of complex systems.

In IISiBât components and projects are stored in object-oriented libraries. Air flow components are arranged in a "tree structure," as illustrated for duct fittings in Figure 5. When a family of components (e.g., duct fittings) is selected, the tree develops to show various component types. Physical properties are attached to each component. Figure 6 shows an air flow network with the boundary conditions as developed with IISiBât.

A building described by its network of air flow components is constructed by assembling joining components together in the assembly window. If a building is too complex to be displayed in all its details, the system can be simplified by using "macro-components." Whole building floors with all their air flow paths and boundary conditions can be displayed as single "macro-components." Once the network is ready for simulation, the calculation process is started from IISiBât.

EVALUATION OF MULTIZONE AIR FLOW MODELS

There is a lack of measured infiltration and ventilation data for whole buildings. These data are essential for validating air flow models. Critical variables must be identified for different building types in order to develop more accurate input data and, ultimately, more accurate models. Wind pressure coefficients, for example, need further study; and the collation of existing data could help our efforts in simplifying data requirements.

The difficulty of measuring infiltration in buildings under controlled boundary conditions means that none of the multizone models has been validated properly, if at all. The possibility of doing piecemeal validations of certain algorithms has been considered (e.g., the algorithms for air flow through open doorways or air flow through cracks). Measuring a few zones of the whole structure would effectively test existing models. However, validation of a model's performance for whole buildings is preferable, as was done for COMIS.

A variety of tests were performed to make sure that COMIS contained no numerical errors; COMIS simulation results were compared with more than 50 benchmarks for which either an analytical or a numerical solution was obtained. Each of these test cases was developed to check a particular feature of the program. These tests were repeated for each individual program update to be sure that a model improvement did not interfere with already tested program features.

Furthermore, two user tests were developed as a joint contribution by the Air Infiltration and Ventilation Centre and researchers in Switzerland. The first test represented a very simple network in which all openings and pressure boundary conditions were defined. This test, and the comparison of simulation results with analytical solutions, enabled inconsistencies and problems in the code to be quickly identified and rectified.

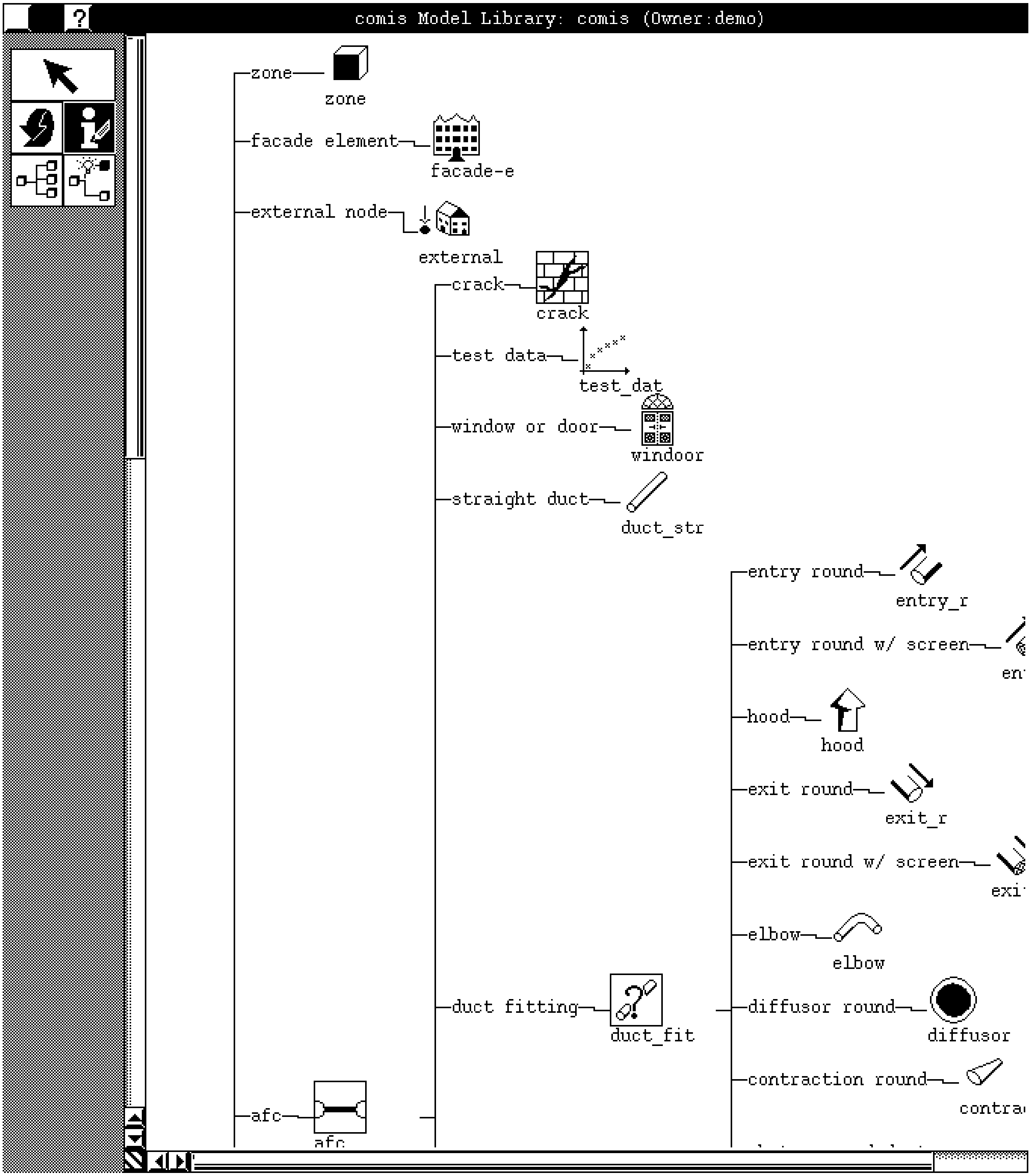

Figure 5: *IISiBât model library (Keilholz 1997)*

A second test was performed to evaluate the influence of the user on the program's accuracy. This test helped us to develop the program documentation, particularly the *User's Guide*. The results showed clearly that the user's ability is critical in securing reliable predictions.

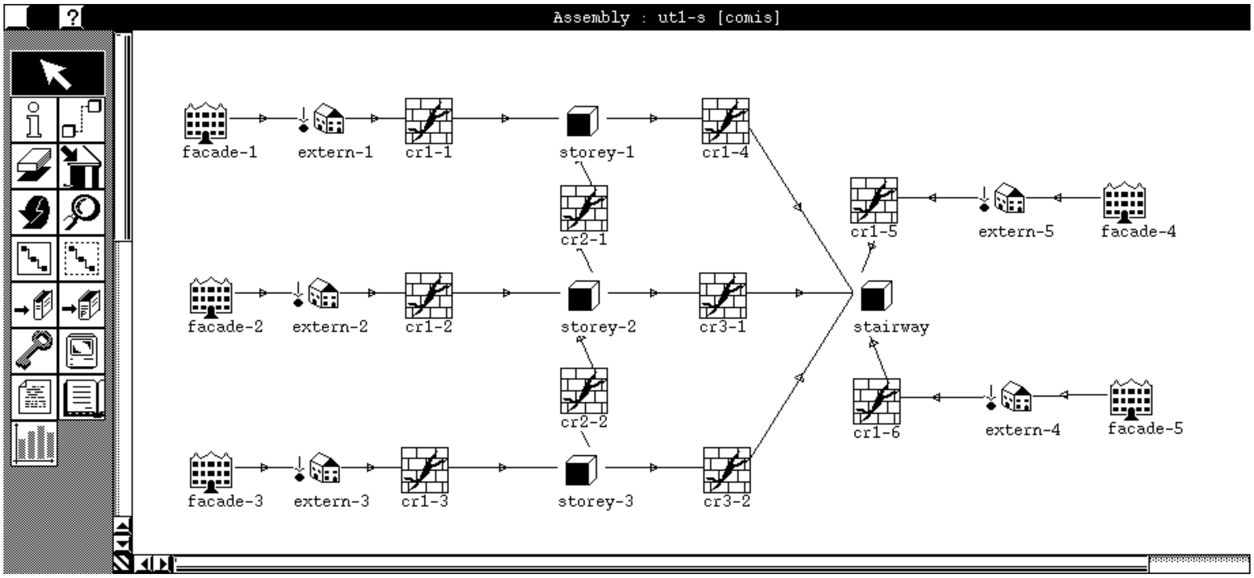

Figure 6: *Air flow network for a three-story building with a common staircase (Keilholz 1997)*

COMIS was also checked by means of model intercomparison. Fourteen other simulation programs were used by the research groups involved in evaluating COMIS and results were compared. Because different programs have different features, the objectives for each intercomparison had to be adapted so that the models to be compared could simulate the same physical phenomenon. Because all programs use similar algorithms, and simulations were performed with identical input data, results fell within a very narrow band.

The comparison of results between the model and in-situ tests was an important part of the work done to develop COMIS. Nine studies were performed using results from tracer gas tests for single-family houses, test cells, flats and small office buildings. These results were compared with results obtained by numerical simulation. For each case, a sensitivity analysis was performed, not only to learn about the uncertainties in the measurements but also about the confidence intervals of the simulations, which result from uncertainties in the input data.

References

Feustel, H.E., 1984 “Beitrag zur theoretischen Beschreibung der Druck- und Luftmassenstromverteilung in natürlich und maschinell gelüfteten Gebäuden,” *Fortschritt-Berichte der VDI Zeitschriften*, Reihe 6, Nr. 151, VDI Verlag, Düsseldorf

Keilholz, W., 1997. “IISiBât/COMIS 3.0 User’s Guide,” http://evl.cstb.fr/iisibat.html

Liddament, M.W., 1986. "Air Infiltration Calculation Techniques - an Applications Guide,” Air Infiltration and Ventilation Centre, Bracknell, U.K.

COMIS on the WWW

- Download COMIS from www-epb.lbl.gov/comis
- COMIS in depth at www.empa.ch/englisch/erg/comis/comis.htm
- COMIS with IISiBât at evl.cstb.fr/francais/projets/IISiBat/

Announcing a New Residential Building Analysis Program

Energy Gauge USA

Residential Energy Analysis & Rating Software

Danny Parker
Principal Research Scientist
Florida Solar Energy Center
1679 Clearlake Road
Cocoa, FL 32922
Phone (407) 638-1405
FAX (407) 638-1439

Energy Gauge USA, developed by the Florida Solar Energy Center (FSEC), allows the simple calculation and rating of residential building energy use in the United States. In the past, most residential analysis and rating software have used modified degree day, correlation or bin methods for calculation of building energy performance. The primary reason for the standard approach has been limitations on computing speed; however, *Energy Gauge USA*, takes advantage of current-generation personal computers that allow hourly annual computer simulations to be completed in less than 30 seconds.

The software, driven by the DOE-2.1E simulation engine, allows users to examine many different energy saving and/or renewable energy options based on the power of a more versatile hourly calculation. The simulation calculates a six-zone model of the residence (conditioned zone, attic, crawlspace, basement, garage and sunspace) with the various buffered spaces linked to the interior as appropriate. TMY weather data for the program are available for 213 locations around the U.S.

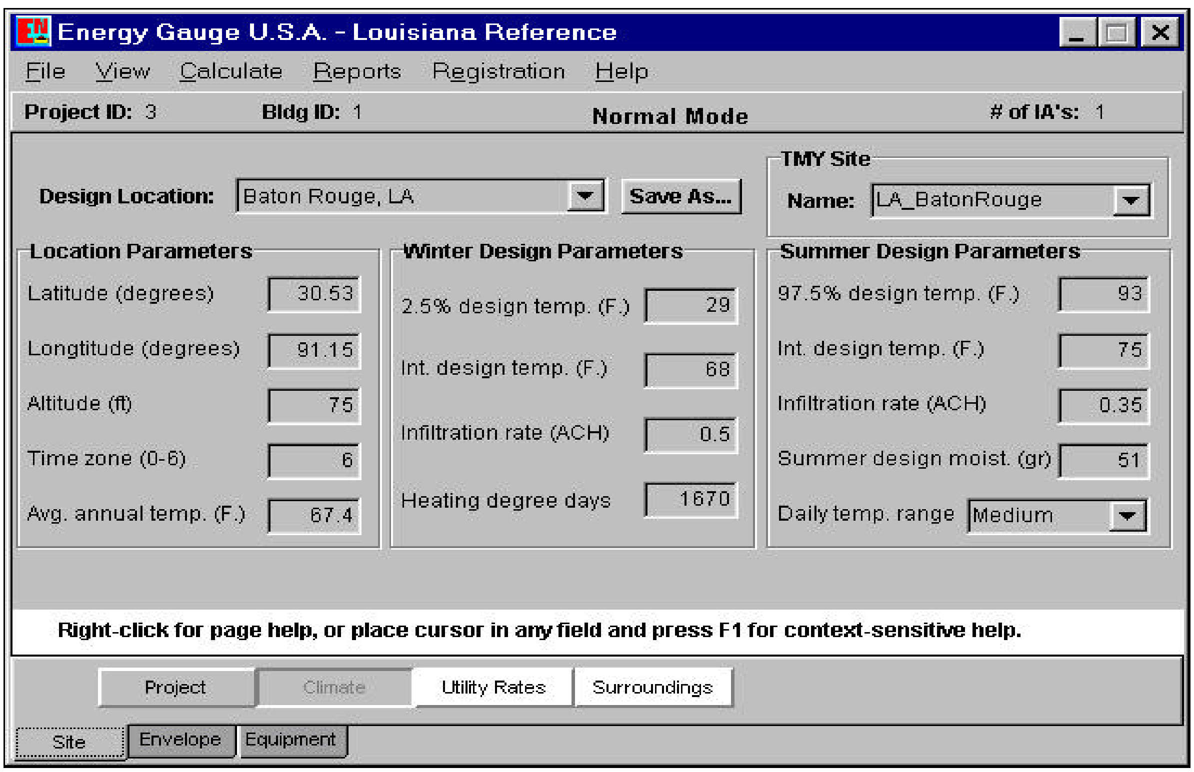

Figure 1: A simplified user interface allows residential buildings to be quickly and easily defined while bringing the computing power and accuracy of an hourly computer simulation to builders, designers and raters.

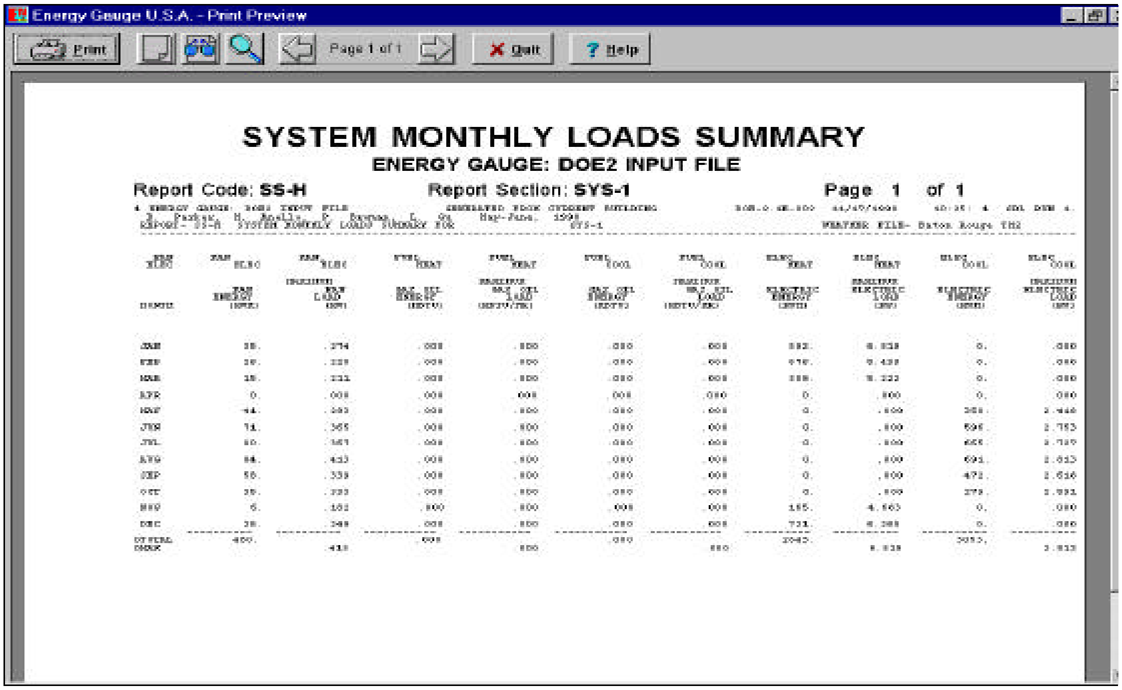

Figure 2:
The current software produces standard DOE-2.1E reports; development will eventually produce customized reports and graphic representation of selected output.

A key objective for the software is to bring the power of building energy simulations to Home Energy Rating System (HERS) scores, assessment of Model Energy Code (MEC) and State energy code compliance along with evaluation of economics of improvements. Also, unlike correlation or bin methods, calculation of hour-by-hour performance allows insight into peak-period impacts of efficiency and renewable technologies by system planners. For instance, the new software would allow users to find out how a changing daily thermostat schedule with a set-up from 9 AM to 5 PM (see the thermostat schedule screen in Fig. 3) will influence coincident peak loads.

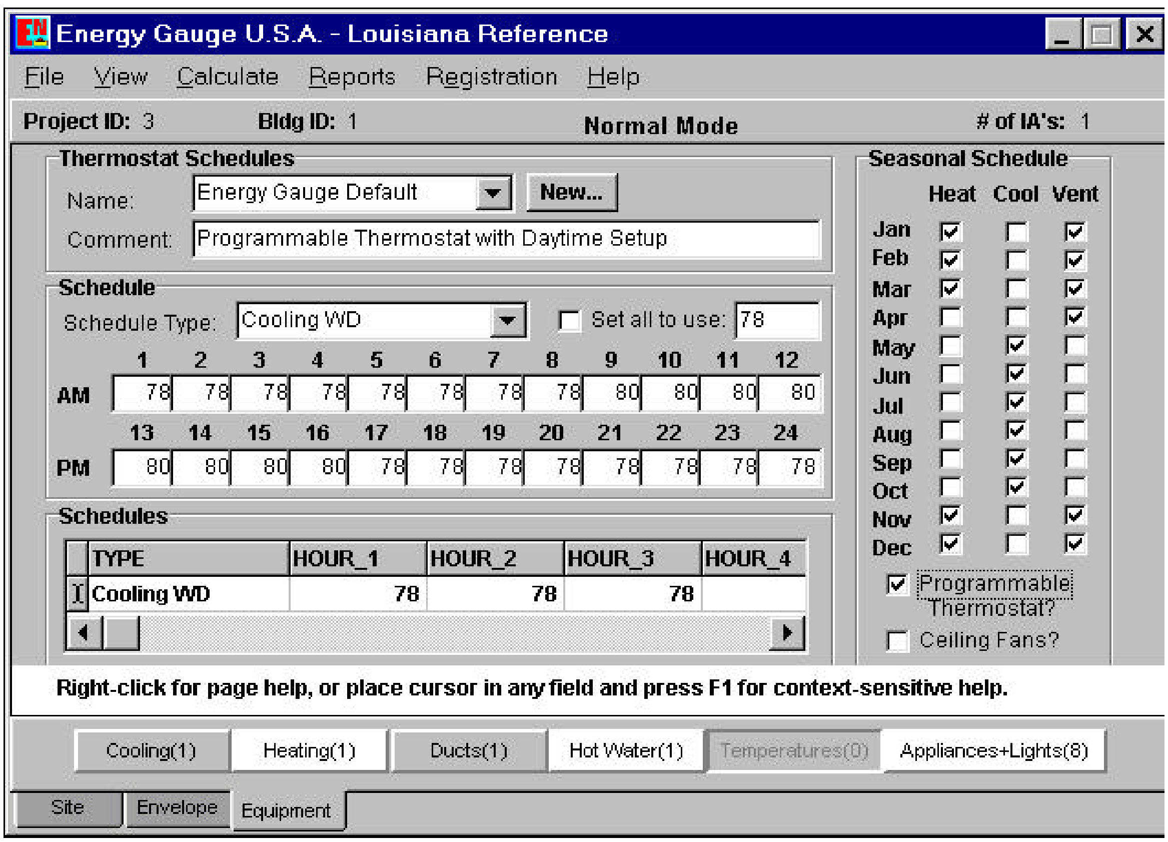

Figure 3:
Thermostat Schedule

Past research, both at FSEC and LBNL, has shown the importance of return duct leakage and duct heat transfer from unconditioned spaces in which the distribution systems are located.[*] In Sunbelt states, such duct systems are often located in the unconditioned attic with a thermal environment that is significantly influenced by roof solar reflectance as well as radiant barriers, increased ventilation and roofing materials.

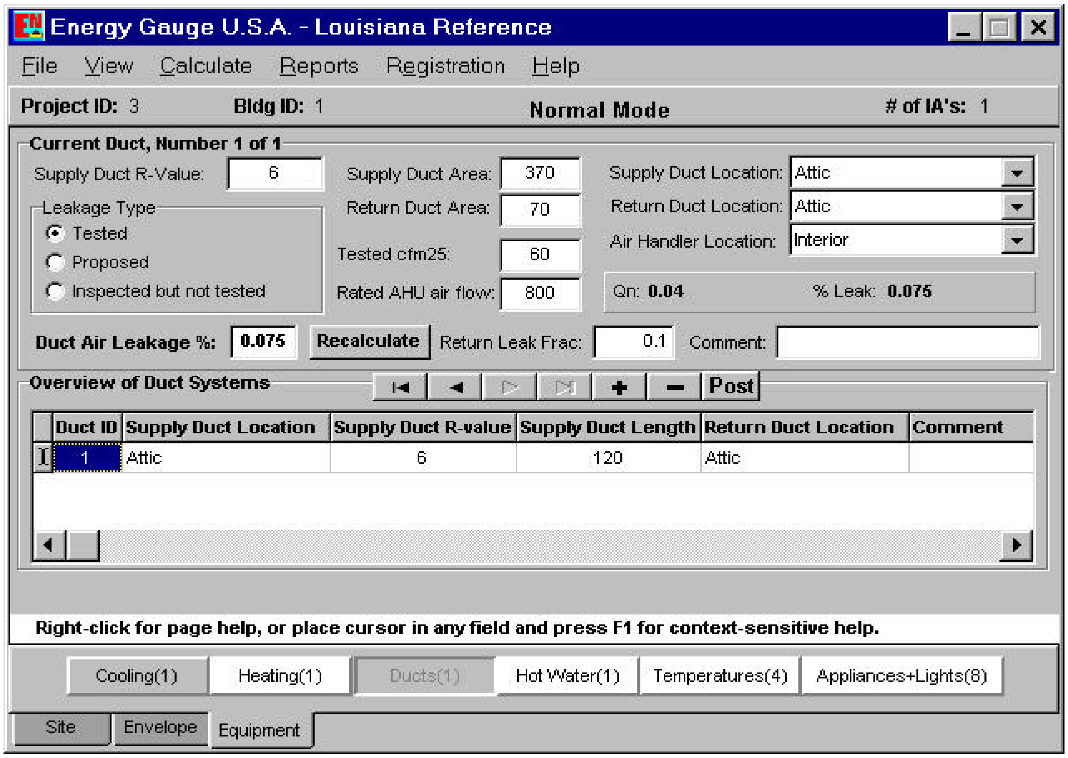

Figure 4: A key capability of *Energy Gauge USA* allows the simulation of the interaction of duct air distribution systems and their location (attic, interior, crawlspace, basement).

Unique capabilities of current software

- Simulation of the impact of duct system leakage and heat transfer on building thermal performance depending on duct location and tested performance parameters.
- Impact of light colored building surfaces on annual cooling and heating performance and indirect impacts on duct systems when located in the attic space.
- Evaluation of performance of advanced glazing products and interaction with interior and exterior shading.
- Assessment of the energy impacts of various building ventilation approaches.
- Characterization of appliance and lighting loads along with interactions with space heating and cooling.

Capabilities under Development

- Formatted output capable of use within HERS, MEC and Energy Efficient Mortgage programs.
- Characterization of solar hot water (SHW) and photovoltaic (PV) systems performance against hour by hour building loads.

Status

Energy Gauge USA is available for alpha testing by a limited number of users. For further information, contact Danny Parker at dparker@fsec.ucf.edu

[*] See D.S. Parker, Y.J. Huang, S.J. Konopacki, J.R. Sherwin and L. Gu, 1998. "Measured and Simulated Performance of Reflective Roofing Systems in Residential Buildings," ASHRAE Transactions, 1998 Winter Meeting, San Francisco, CA.

What's New? (continued from front page)

¨ **New Consultants ...**

Welcome to Patrick Nkwocha, P.E., Director of Engineering for **Global Tech Services,** an engineering firm that specializes in energy analysis for school modernization and new construction.

Global Tech Services
3360 Foothill Boulevard #108
Pasadena, CA 91107

Phone: (626) 583-8205
Fax: (626) 583-8206
Email: utat@worldnet.att.net

Long-time DOE-2 user John Aulbach is another new consultant.

John R. Aulbach, P.E.
23508 Naffa Avenue
Carson, CA 90745

Phone and Fax: (310) 549-7118
Email: jrascab36@earthlink.net

¨ **Update Your Address Books ...**

The **Heshong Mahone Group (HMG)** of Fair Oaks (Sacramento), CA, has moved. The new address is

Heshong Mahone Group
11626 Fair Oaks Boulevard, Suite 302
Fair Oaks, CA 95628

Phone: (916) 962-7001
Fax: (916) 962-0101

In addition to being a partner in HMG, Doug Mahone is also the Executive Director of **The New Buildings Institute**, a non-profit organization created in late 1997. See p. 37. The New Buildings Institute is one of the featured web sites in this issue.

Consultant Gopal Shiddapur, formerly of Connecticut, has a new address:

Gopal Shiddapur, P.E.
Mail Code: ST05A
DukeSolutions
230 South Tryon Street, Suite 400
Charlotte, NC 28202

Phone: (704) 373-4439
Fax: (704) 373-4872
Email: gsshidda@duke-energy.com

User News Deadlines for 1999-2000

Shaded days on the calendar indicate deadline dates for either submission of articles or changes to vendor information. We always welcome articles about innovative uses for DOE-2, BLAST and their derivatives.

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                          1999
      Jan          |       Feb         |        Mar
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                          2000

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---------------------------------------------------------
      Apr          |       May         |        Jun
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17 18 19 20 21     | 15 16 17 18 19    | 12 13 14 15 16
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                   | 29 30 31          | 26 27 28 29 30
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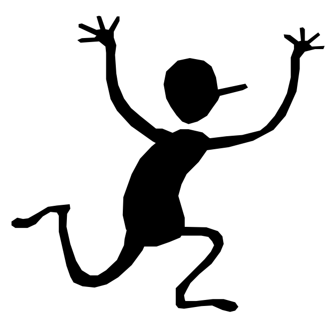
The newsletter is usually mailed out three to four weeks after the deadline.



"Building Loads Analysis and System Thermodynamics"

blastnews

Building Systems Laboratory (BSL)

30 Mechanical Engineering Building
University of Illinois
1206 West Green Street
Urbana, IL 61801

Telephone: (217) 333-3977
FAX: (217) 244-6534
e-mail: support@blast.bso.uiuc.edu
http://www.bso.uiuc.edu

The **Building Loads Analysis and System Thermodynamics (BLAST)** system is a comprehensive set of programs for predicting energy consumption and energy system performance and cost in buildings. The BLAST system was developed by the U.S. Army Construction Engineering Research Laboratory (USACERL) under the sponsorship of the Department of the Air Force, Air Force Engineering and Services Center (AFESC), and the Department of the Army, Office of the Chief of Engineers (OCE). After the original release of BLAST in December 1977, the program was extended and improved under the sponsorship of the General Services Administration, Office of Professional Services; BLAST Version 2.0 was released in June 1979. Under the sponsorship of the Department of the Air Force, Aeronautical System Division, and the Department of Energy, Conservation and Solar Energy Office, the program was further extended; BLAST Version 3.0 was completed in September 1980. Since 1983, the BLAST system has been supported and maintained by the Building Systems Laboratory at the University of Illinois at Urbana-Champaign.

BLAST can be used to investigate the energy performance of new or retrofit building design options of almost any type and size. In addition to performing peak load (design day) calculations necessary for mechanical equipment design, BLAST also estimates the annual energy performance of the facility, which is essential for the design of solar and total energy equipment design, BLAST also estimates the annual energy performance of the facility, which is essential for the design of solar and total energy (cogeneration) systems and for determining compliance with design energy budgets. Repeated use of BLAST is inexpensive; it can be used to evaluate, modify, and re-evaluate alternate designs on the basis of annual energy consumption and cost.

The BLAST analysis program contains three major subprograms:

- The Space Load Prediction subprogram computes hourly space loads in a building based on weather data and user inputs detailing the building construction and operation.
- The Air Distribution System Simulation sub-program uses the computed space loads, weather data, and user inputs describing the building air- handling system to calculate hot water, steam, gas, chilled water, and electric demands of the building and air-handling system.
- The Central Plant Simulation subprogram uses weather data, results of the air distribution system simulation, and user inputs describing the central plant to simulate boilers, chillers, on-site power generating equipment and solar energy systems; it computes monthly and annual fuel and electrical power consumption.

Heat Balance Loads Calculator (HBLC)
The BLAST graphical interface (HBLC) is a Windows-based interactive program for producing BLAST input files. HBLC allows the user to visualize the building model as it is developed and modify previously created input files. Within HBLC, each story of the building is represented as a floor plan which may contain several separate zones. Numerous other building details may be investigated and accessed through simple mouse operations. On-line helps provide valuable on-the-spot assistance that will benefit both new and experienced users. HBLC is an excellent tool which will make the process of developing BLAST input files more intuitive and efficient. You can download a demo version of HBLC (for MS Windows) from the BLAST website (User manual included!).

HBLC/BLAST Training Courses
The BLAST graphical interface (HBLC) is a Windows-based interactive program for producing Experience with the HBLC and the BLAST family of programs has shown that new users can benefit from a session of structured training with the software. Such training helps to define the steps necessary to produce accurate and consistent output from BLAST and its auxiliary programs and gives users a solid foundation from which they can explore the more advanced features of the program with confidence. The Building Systems Laboratory offers such training courses on an as needed basis typically at our offices in Urbana, Illinois and lasting 2 or 3 days depending on the specific needs of the participants. Call the Building Systems Laboratory for additional information on pricing and availability.

WINLCCID 98
LCCID (Life Cycle Cost in Design) has been a standard in the DOD community since its initial release in 1986. LCCID was developed to perform Life Cycle Cost Analyses (LCCA) for the Department of Defense and their contractors, yet it goes far beyond being just a DOD study tool by providing many features of a general purpose life cycle costing tool. With LCCID, it's easy to carry out "what-if" analyses based on variables such as present and future costs and/or maintenance and repair costs. LCCID allows an analysis based on standard DOD procedures and annually updated escalation factors as well as Energy Conservation Investment Program (ECIP) LCCA. You can download a demo version of WINLCCID 98 (for MS Windows) from the BLAST website http://www.bso.uiuc.edu [see *User News* Vol. 16, No. 4, p. 5]

To order BLAST-related products, contact the Building Systems Laboratory at the University of Illinois at Urbana-Champaign.

BLAST Order Information

Program Name	Order Number	Price Each
PC BLAST Package The standard PC BLAST Package includes the following programs: BLAST, HBLC, BTEXT, WIFE, CHILLER, Report Writer, Report Writer File Generator, Comfort Report program, Weather File Reporting Program, Control Profile Macros for Lotus or Symphony, and the Design Week Program. The programs are provided on a single CD-ROM which also includes soft copies of the BLAST Manual, 65 technical articles and theses related to BLAST, nearly 400 processed weather files with an easy-to-use browsing engine, and complete source code for BLAST, HBLC, and other programs in the BLAST package. Requires an IBM PC 486/Pentium II or compatible running MS Windows 95/98/NT.	3B486E3-0898	$1500.00
PC BLAST Package Upgrade from level 295+	4B486E3-0898	$450.00
WINLCCID 98: executable version for 386/486/Pentium	3LCC3-0898	$295.00
WINLCCID 98: update from WINLCCID 97	4LCC3-0898	$195.00

The last four digits of the catalog number indicate the month and year the item was released or published. This will enable you to see if you have the most recent version. All software will be shipped on 3.5" high density floppy disks unless noted otherwise.

DOE-2 Directory of Program Related Software and Services†

Mainframe/Workstation Versions of DOE-2

Program Name	Operating System	Description	
DOE-2.1E From the Energy Science and Technology Software Center (ESTSC)	SUN-4 DEC-VAX	Source code, executable code and complete current documentation for: DOE-2.1E/Version 094 for SUN-4 DOE-2.1E DEC-VAX	For a complete listing of the software available from ESTSC, order their "Software Listing" catalog, ESTSC-2. [See *User News* Vol. 16, No. 3, p. 21]
FTI/DOE (see FTI/DOE listing under PC Versions of DOE-2, below)			

PC Versions of DOE-2

Program Name	Operating System	Description
ADM-DOE-2 Based on J.J. Hirsch DOE-2.1E	DOS Windows 95	ADM-DOE-2 (DOE-2.1E) is compiled for use on 386/486 PCs with a math co-processor and 4MB of RAM. The package contains everything needed to run the program: program files, utilities, sample input files, and weather files. More than 300 weather files are available (TMY, TRY, WYEC, CTZ formats) for the U.S. and Canada. [See *User News* Vol. 7, No. 2, p. 6]
Compare-IT Based on J.J. Hirsch DOE-2.1E	Windows (98, 95, NT)	Compare-IT allows DOE-2 professionals to add value to their projects by giving clients "what-if" scenarios using DOE-2. The interface is designed for novice energy analysts and the GUI can be customized for each client's particular interests. A tabbed main window is configured based on the user's DOE-2 macro organization. All labels, drop-down list boxes, tool-tips, error checking, and help files are created dynamically from a "Compare-IT-ized" DOE-2 input file. Output are tables and powerful graphs of annual costs, annual energy and end-use and hourly end-use values. [See *User News* Vol. 19, No. 1]
DOE-PLUS Based on J.J. Hirsch DOE-2.1E Demo: www.halcyon.com/byrne	DOS Windows (3.1, 95, NT)	Complete support for all DOE-2 commands. Imports BDL files created with a text editor or other program. Interactive error checking. 3-D view of building can be rotated and zoomed. Windows, walls, etc., identified by DOE-2 U-name and allow component editing. User-defined libraries of schedules, HVAC systems, plant equipment, building components, etc. Exports results to spreadsheets and database programs. Graphical display of schedules. Utility programs included: Prep, Demand Analyzer, weather processor. Over 500 worldwide weather files. [See *User News* Vol. 13, No. 2, p. 54, Vol. 16, No. 1, p. 28-32]
EnergyPro Based on ESTSC DOE-2.1E V. 092 Demo: www.energysoft.com	Windows (95, NT)	Performs nonresidential load calculations for HVAC equipment sizing. Produces typeset quality reports/forms. Electronically exports forms to AutoCad for inclusion on blueprints. On-line help. 344 weather files for the U.S. and Canada. For California Users: Performs Title 24 compliance calculations, includes state-certified HVAC and DHW Equipment directories, Title 24 tailored lighting calculations. [See *User News* Vol. 18, Nos. 2, 4]
EZDOE Based on J.J. Hirsch DOE-2.1D Demo: www.elitesoft.com	DOS	Provides full screen, fill-in-the-blank data entry, dynamic error checking, context-sensitive help, mouse support, graphic reports, a 750-page user manual, and extensive weather data. EZDOE integrates the full calculation modules of DOE-2 into a powerful, full implementation of DOE-2 on DOS-based 386 and higher computers. On-line help. Includes some weather files. *[See User News Vol. 14, No. 2, p. 10 and No. 4, p. 8-14]*
FTI/DOE Based on ESTSC DOE-2.1E V. 092 No demo, 30-day trial period	DOS Windows (3.x, 95, NT) AIX, ULTRIX, VMS, Linux, NeXTStep,	FTI/DOE is 100% compatible with LBNL version. Highly optimized and extremely reliable. Version 3.1 will include a graphical user interface and will provide full command functionality and access to all reporting features of the original. Interface is Java-based and will be available for any system supporting Java. Source code versions will compile with most F77-compliant compilers. On-line help: Yes for Version 3.x, No for Version 2.x. 344 weather files for the U.S. and Canada. *[See User News Vol. 12, No. 4, p. 16]*

† This information is based on a December 1997 survey of DOE-2 product vendors.

DOE-2 Directory of Program Related Software and Services

Mainframe/Workstations Versions of DOE-2

Input / Output	Support	Program Price	Vendor Information
	Limited "operational" support, which includes telephone assistance concerning installation, media or platform questions.	SUN version: Govt/Educ $400 U.S., Mexico, Canada $1305 Other Foreign $2000 VAX version: Govt/Educ $500 U.S., Mexico, Canada $1835 Other Foreign $2716	**Energy Science and Technology Software Center** P.O. Box 1020 Oak Ridge, TN 37831-1020 Ph: 423-576-2606 / Fx: 423-576-2865 ESTSC@ADONIS.OSTI.GOV www.doe.gov/html/osti
FTI/DOE (see FTI listing under PC Versions of DOE-2, below)			

PC Versions of DOE-2

Input / Output	Support	Program Price	Vendor Information
No information given No information given	None	$395 + $15/SH including one set weather data (your choice) and documentation	**ADM-DOE- 2** **(Richard Burkhart)** ADM Associates adm_asc@ns.net 3239 Ramos Circle Sacramento, CA 95827-2501 Ph: 916-363-8383 / Fx: 916-363-1788
Customizable windows GUI dynamically built based on DOE-2 macros. Tables and graphs exportable to MS Excel 97. Custom reports dynamically generated in Word 97.	Support price is negotiable; online help included with the program.	$500 consultant $2000 client Documentation available	**Compare-IT** **(Ed Erickson)** RLW Analytics 1055 Broadway, Suite G Sonoma, CA 95476 Ph: 707-939-8823 / Fx: 707-939-9218 Info@rlw.com or www.rlw.com
Interactive, graphical, fill-in-the-blanks Customizable tables and graphics	Unlimited, except for DOE-2 modeling advice. On-line help.	$895 with DOE-2 and doc $495 without DOE-2 Source code not available.	**DOE-Plus** **(Steve Byrne)** Item Systems 321 High School Road NE #344 Bainbridge Island, WA 98110 Ph: 206-855-9540 / Fx: 206-855-9541 byrne @ item.com
Graphical Graphs, forms	Unlimited support	DOE-2 Module: Non-residential $ 700[1,2] Residential $ 250[1,2] Program Interface $ 195[3] [1] price reflects cash discount [2] includes documentation [3] required	**EnergyPro** **(Demian Vonderkulen)** Gabel Dodd/EnergySoft LLC 100 Galli Drive #1 Novato, CA 94949-5657 Ph: 415-883-5900 / Fx: 415-883-5970 demian@energysoft.com
Fill-in-the-blanks Standard DOE reports plus some custom graphic reports	Unlimited phone support	$1295 w/documentation Source code not available.	**EZDOE** **(Bill Smith)** Elite Software P.O. Box 1194 Bryan, TX 77806 Ph: 409-846-2340 / Fx: 409-846-4367 bsmith @ elitesoft.com
Version 2.x: text based Version 3.x: graphical All standard DOE-2 reports Run time and status graphics	Free support for 90 days from date of purchase. After 90 days, support is: $35 email per incident $55 hour per incident $125 per hour for engineering advice. Bugs reports free.	$ 995.99 US w/documentation $1066 Int'l w/documentation $4999.99 source code	**FTI/DOE2** **(Scott A. Henderson)** Finite Technologies Inc. 3763 Image Drive Anchorage, Alaska 99504 Ph: 907-333-8937 / Fx: 907-333-4482 info @ finite-tech.com

Continued on next page

Caveat : We list third-party DOE-2-related products and services for the convenience of program users, with the understanding that the Simulation Research Group does not have the resources to check the DOE-2 program adaptations and utilities for accuracy or reliability.

DOE-2 Directory of Program Related Software and Services (continued)

PC Versions of DOE-2 (continued)

Program Name	Operating System	Description
MICRO-DOE2 Based on ESTSC DOE-2.1E V. 088 Demo: call vendor	DOS Windows (3.1, 95, NT)	Widely-used, reliable, and tested. Includes automatic weather processing, batch file creation, and a *Users Guide* with instructions on how to set up a RAM drive. System requirements: 386/486 PC with 4 Mb of RAM and math co-processor. Optional BDL-Builder simplifies input (see "Pre- and Post-Processors for DOE-2). On-line help. Program includes some weather files. [See *User News* Vol. 7, No. 4, p. 2; Vol. 11, No. 1, p. 2; Vol. 15, No. 1, p. 8; Vol. 15, No. 3, p. 4; Vol. 16, No. 2, p. 1,7; Vol. 16, No. 4, p. 7-8]
Perform-95 Based DOE-2.1E No demo	DOS	Created for the State of California Energy Commission's, Title 24 energy code. Perform-95 is an interface shell with DOE-2 as the engine.
PRC-DOE-2 Based on J.J. Hirsch DOE-2.1E No demo	DOS Windows (95, NT)	This text-based version of DOE-2 is fast, reliable, and very up to date. Documentation includes 2.1E Supplement, 2.1E BDL Summary; original Reference Manual available. Extensive information on new features is included on the disk as well, including information on new system types, new commands, new options, etc., added to later versions of 2.1E.
VisualDOE2.6 Based on J.J. Hirsch DOE-2.1E, V. 083 Demo: www.eley.com	DOS Windows (3.1, 95, NT)	Dramatically faster construction of building geometry using pre-defined blocks and/or drawing interface. Import zone shapes from CADD file (dxf format). Point-and-click to define zone properties and HVAC systems. Define up to 20 design alternatives in each project file. View rotatable 3-D image of model. Create custom hourly output reports and customized graphs. Edit and expand library of constructions, schedules, equipment, and utility rates. Add custom performance curves. Network version allows sharing of libraries. On-line help. 400+ weather files for the U.S., 12+ weather files for Canada, plus selected locations around the world. *[See User News Vol. 15, No. 2, p. 10; Vol. 16, No. 4, p. 9-16; Vol. 17, No. 4, p. 8-13]*

Pre- and Post-Processors for DOE-2

Program Name	Description
BDL Builder and **E2BB**	**BDL Builder** is a user-friendly Windows-implemented pre-processor for DOE-2.1E that allows the description of specific building and HVAC characteristics with numeric input by preparing databases, or building blocks, and then selecting records from the databases to assemble a complete input. **E2BB** translates existing DOE-2.1E text input to **BDL Builder**.
DrawBDL	**DrawBDL,** Version 2.02, is a graphic debugging and drawing tool for DOE-2 building geometry. DrawBDL reads your BDL input and makes a rotatable 3-D drawing of your building with walls, windows, and building shades shown in different colors for easy identification. *[See User News, Vol. 14, No. 1, p. 5-7, Vol. 14, No. 4, p. 16-17, and Vol. 16, No. 1, p.37]*
Visualize-IT (Visual Data Analysis Tools)	The ***Energy Information Tool*** is used to review and understand metered or DOE-2.1E hourly output data. It provides the ability to see all 8760 (or 35040) data points for a year's worth of data. Use *Energy/Print* to get an overview of the data and then apply a variety of tools (load shapes, load duration curves, etc.). The ***Calibration Tool*** compares DOE-2.1E hourly output data to total load and/or end-use metered data. Options include monthly demand and load 2D graphs, maximum and seasonal load shapes, average load profiles, end use residuals, monthly average week and weekend days, and dynamic comparison load shapes. Both programs requires a 486 or higher computer and SVGA graphics capabilities. *[See User News Vol. 17, No. 2, p. 2-6]*
PRC-TOOLS: **PRC-Grab** **PRC-Hour** **PRC-Peak**	***PRC-Tools*** aid in extracting, analyzing, and formatting DOE-2 output. ***PRC-Grab*** automates the process of extracting any number of answers from DOE-2 standard output files. ***PRC-Hour*** and ***PRC-Peak*** format the hourly output and create Peak-Day and Average-Day load shapes for any number of periods and for any combination of hourly values.

DOE-2 Directory of Program Related Software and Services

PC Versions of DOE-2 (continued)

Input / Output	Support	Program Price	Vendor Information
Fill-in-the-blanks	Assistance provided to install and initially use program. Reasonable support thereafter. Training available at Users office. Support price negotiated individually.	$500 w/documentation Source code available, call for price.	**MICRO-DOE2 (Don Croy)** Acrosoft/CAER Engineers 1204-1/2 Washington Avenue Golden, CO 80401 Ph: 303-279-8136 / Fx: 303-279-0506 102447.2611@compuserve.com
Standard text-based / Output is only California Title 24 compliant.	Technical support available for $100/year from Gabel-Dodd Energy Soft LLC, 100 Galli Drive #1, Novato, CA 94960. Call 415-883-5900 for details..	$250 including Perform-95 manual. Order #P440-96-0006	**California Energy Commission** Publications MS-13 P.O. Box 944295 Sacramento, CA 94244-2950 Contact the Energy Hotline (in California, call 800-772-3300) at Ph: 916-654-5106
Standard text-based	Unlimited support.	$ 495 w/documentation Source code not available.	**PRC-DOE-2 (Paul Reeves)** Partnership for Resource Conservation 140 South 34th Street Boulder, CO 80303 Ph: 303-499-8611 / Fx: 303-554-1370 Paul.Reeves@DOE2.com
Graphical / Graphical	90 days free phone and email support. Support is $195 per year after first 90 days	$495 w/documentation Source code not available.	**VisualDOE2.6 (C. Eley or Erik Kolderup)** Charles Eley Associates 142 Minna Street San Francisco, CA 94105 Ph: 415-957-1977 / Fx: 415-957-1381 support@eley.com

Pre- and Post-Processors for DOE-2

Operating System	Works with this version of DOE-2	Price	Vendor
Dos or Windows 3.1, 95	All DOE-2.1E standard versions	BDL Builder $750.00 E2BB $45.00	**MICRO-DOE2 (Don Croy)** Acrosoft/CAER Engineers 1204-1/2 Washingtin Avenue Golden, CO 80401 Ph: 303-279-8136 / Fx: 303-279-0506 102447.2611@compuserve.com
Windows 3.1, 95, NT	DOE-2.1E	$125.00 plus shipping	**Joe Huang & Associates** 6720 Potrero Avenue El Cerrito, CA 91364 Ph/Fx: 510-236-9238
Windows 3.1	DOE-2.1E		**RLW Analytics, Inc. (Ed Erickson)** 1055 Broadway, G Sonoma, CA 95476 Ph: 707-939-8823 Fx: 707-939-9218 Info@rlw.com www.rlw.com
Windows 95, NT	All versions of DOE-2	$99.00	**Partnership for Resource Conservation** 140 South 34th Street **(Paul Reeves)** Boulder, CO 80303 Ph: 303-499-8611 / Fx: 303-554-1370 Paul.Reeves@DOE2.com

Index to the User News

Vol. 1, No. 1 (August 1980) through Vol. 19, No. 4 (Winter 1998)

KEY: The Index lists User News volumes, issues, and page numbers as follows: title of the article, program version that was current when article appeared, Volume, Number (No. 1 = Spring, No. 2 = Summer, No. 3 = Fall, No. 4 = Winter), and page number. For example, the entry "Advanced Simulation (2.1C)...7:4,4-8" means that the article was entitled "Advanced Simulation" and it was printed when DOE-2.1C was the current version of the DOE-2 program; the article appeared in Volume 7:Number 4, on pages 4 through 8.

DOE-2.1E Bug Fixes via FTP

If you have Internet access you can obtain the latest bug fixes to the LBNL version of DOE-2.1E by anonymous ftp. Here's how…

ftp to either gundog@lbl.gov or to 128.3.254.10
login: *type* anonymous
password: *type in your e-mail address*

After logging on, go to directory pub/21e-mods ; bug fixes are in files that end with **.mod** . A description of the fixes is in file **VERSIONS.txt** in directory **pub** . Each fix has its own version number, ***nnn*** , which is printed out as DOE-2.1E- *nnn* on the DOE-2.1E banner page and output reports when the program is recompiled with the fix. You may direct questions about accessing or incorporating the bug fixes to Ender Erdem (aeerdem@lbl.gov).

Meetings, Conferences, Symposia

Int'l Conference on Renewable/Advanced Energy Systems for the 21st Century

To be held
April 11-14, 1999
Lahaina, Maui, HI

Contact:
Dawna Rosenkranz
Texas A&M University

Tel: 409.847.8950
Fax: 409.862.8687

ASHRAE Annual Meeting

To be held
June 19-23, 1999
Seattle, WA

Contact:
ASHRAE Meetings Section
1791 Tullie Circle NE
Atlanta, GA 30329

Tel: 404.636.8400
Fax: 404.321.5478
jyoung@ashrae.org
www.ashrae.org

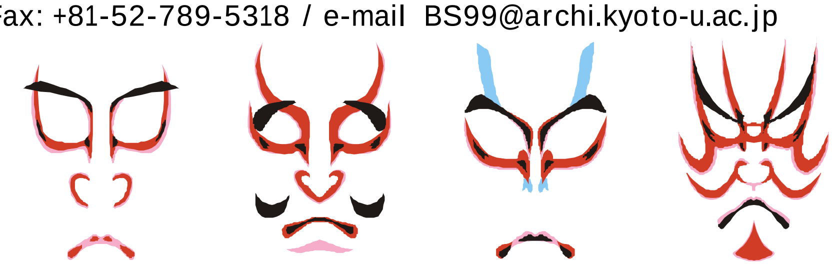
IBPSA's Building Simulation '99

To be held September 13-15, 1999
Kyoto, Japan

Call for Papers go to www.mae.okstate.edu/ibpsa; refer to the IBPSA web page for all deadlines.

Contact
Masaya Okumiya
CIRSE
Nagoya University
Furo-cho, Chikusa-ku,
Nagoya 464-8603 Japan

Fax: +81-52-789-5318 / e-mail BS99@archi.kyoto-u.ac.jp



Disclaimer

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INTERNATIONAL DOE-2 RESOURCE CENTERS

The people listed here have agreed to be primary contacts for DOE-2 program users in their respective countries. Each resource center has the latest program documentation, all back issues of the User News, and recent LBNL reports pertaining to DOE-2. These resource centers will receive copies of all new reports and documentation. Program users can then make arrangements to get photocopies of the new material for a nominal cost. We hope to establish resource centers in other countries; please contact us if you are interested in establishing a center in your area.

Australasia

Dr. Deo K. Prasad/P. C. Thomas, SOLARCH, University of New South Wales, P.O. Box 1, Kensington, N.S.W. 2033, Australia email PC.Thomas@unsw.EDU.AU / Tel: (61)-2-9311-7136 (P.C. Thomas) / Fax: (61) 2-9662-1378

Australia

Murray Mason, ACADS BSG, 16 High Street, Glen Iris VIC. 3146, Australia / Tel: (61) 885 6586 / Fax: 885 5974

Egypt

Dr. Ossama A. Abdou, Center for Building Environmental Studies and Testing (C-Best), 15-El-Shibani Street, Almanza, Cairo, Egypt oabdou@hotmail.com / Tel: (20-2) 391-1137 or 417-4583 / Fax: 519-4343

Germany

B. Barath or G. Morgenstern, Ingenieurbüro Barath & Wagner GmnH, Postfach 20 21 41, D-41552 Kaarst, Germany Tel: (0049) 2131 75 74 90 12 G. Morgenstern / Fax: (0049) 2131 75 74 90 29

Hong Kong, China, Taiwan, Japan

Dr. Sam Chun-Man HUI or K.P. Cheung, Department of Architecture, The University of Hong Kong, Pokfulam Road, Hong Kong (SAR), CHINA / cmhui@hku.hk / http://arch.hku.hk/research/BEER/DOE-2/DOE-2.htm
Tel: (852) 2123 (direct to Sam Hui) / Fax: (852) 2559-6484 / Hui pager 7116 3808 a/c 1830

Korea (Chungnam)

Dr. Jun Tae KIM, Room #114 New Engineering Building, Department of Architectural Engineering, Faculty of Engineering, Kong Ju National University, 182 Sinkwan-dong, Kongju, Chungnam, 314-701, Republic of Korea / jtkim@knu.kongju.ac.kr / Tel: (82) 416 50 8653 / Fax (82) 416 856 9388

Korea (Taejon)

Dr. Euy-Joon Lee and Jong-Ho Yoon, Passive Solar Research Team, Building 2 / Room 202, Korea Institute of Energy Research (KIER), Daeduk Science Town, 71-2 Jang-Dong, Yusong-Gu, Taejon 305-343, Republic of Korea
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New Zealand

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Portugal, Spain, Italy, and Greece

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Prof. Roberto Lamberts,Universidade Federal de Santa Catarina, Campus Universitario-Trindade, Cx. Postal 476, 88049-900 Florianopolis SC, BRASIL lamberts@ecv.ufsc.br / Tel: + 55 48 3319272/ Fax: + 55 48 3319770

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INTERNATIONAL DOE-2 ENERGY CONSULTANTS

Belgium

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Neil A. Caldwell, PE, Tescor Pacific Energy Services, Inc., 1730 - 401 W. Georgia St., Vancouver, BC V6B 5A1 Canada caldwell@tescor.dwg.com / http://www.dwg.com/tescor

Stephane Bilodeau, PE, Groupe Enerstat, Inc., 79 Wellington N. #202, Sherbrooke (Quebec) J1H 5A9, Canada bill@aramis.gme.usherb.ca / Tel: (819) 562-8040 / Fax (819) 562-5578

Gordon Shymko, G.F. Shymko & Associates, Inc., 202-1738 Alberni Street, Vancouver, BC V6G 1B2 Canada gshymko@direct.ca / Tel: (604) 685-5350 / Fax: (604) 685-5301

Germany

Jens Grundt and Ludwig Michel, GMW-Ingenieurburo, Vahrenwalder Str. 7, D-30165 Hannover, Germany GMW-Ing.buero@t-online.de / Tel: 0049-511 9357440/Fax 0049-511-935744

New Zealand

Paul Bannister Energy Group, Ltd., 14a Wickliffe Street (P.O. Box 738), Dunedin New Zealand
eglstaff@earthlight.co.nz

Switzerland

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Philip Schluchter, Institut fur Bauphysik Klein, Urs Graf-Strasse 1, CH4052 Basel, Switzerland

Gerhard Zweifel, Zentralschweizerisches Technikum Luzern (ZTL), Abt. HLK, CH-6048 Horw, Switzerland gzweifel@ztl.ch

Joerg Tscherry, Building Equipment Section 175, EMPA, 129 Überlandstrasse, CH-8600 Dübendorf, Switzerland

Resource Center News

- **Two New Resource Centers: Egypt and Korea**

  Dr. Ossama A. Abdou, who was a DOE-2 user while attending Drexel University, has established a resource center in Cairo, **Egypt**. Dr. Abdou is also president of the Center for Building Environmental Studies and Testing (C-Best), which was established to promote building energy simulation studies for academics and professionals.

  The newest resource center in **Korea** is headed by Dr. Euy-Joon Lee of the Passive Solar Research Team at the Korea Institute of Energy Research in Taejon. There is also a center in Chungnam headed by Dr. Jun Tae Kim.

- **Singapore Address Correction**

  Please change the telephone number and email for Dr. Raymond Wong at the **Singapore** resource center. New phone number is (65) 790 5543; new email is mywwong@ntu.edu.sg.

U. S. DOE-2 ENERGY CONSULTANTS

Arizona				
Marlin S. Addison	M. S. Addison & Associates	1215 West 12th Place	Tempe, AZ 85281	(602) 968-2040
Chuck Sherman	Energy Simulation Specialists	64 East Broadway, #230	Tempe, AZ 85282	(602) 784-4500
Sarat Kanaka	EcoGroup, Inc., Suite 301	2085 E. Technology Circle	Tempe, AZ 85284	(602) 777-3000
California				
M. Gabel, R. Howley	Gabel Associates, LLC	1818 Harmon Street	Berkeley, CA 94703	(510) 428-0803
George Marton	1129 Keith Avenue		Berkeley, CA 94708	(510) 841-8083
Jeff Hirsch	James J. Hirsch Associates	12185 Presilla Road	Camarillo, CA 93012	(805) 532-1045
John R. Aulbach, PE	23508 Naffa Avenue		Carson, CA 90745	(310) 549-7118
Leo Rainer	Davis Energy Group, Inc.	123 C Street	Davis, CA 95616	(916) 753-1100
L. Heshong, D. Mahone	The Heshong Mahone Group	11626 Fair Oaks Blvd, #302	Fair Oaks, CA 95628	(916) 962-7001
Cliff Gustafson	Taylor Systems Engrg. Inc.	9801 Fair Oaks Blvd., #100	Fair Oaks, CA 95628	(916) 961-3400
Steven D. Gates, PE	11608 Sandy Bar Court		Gold River, CA 95670	(916) 638-7540
Tom Lunneberg, PE	Constructive Tech. Group	16 Technology Dr., #109	Irvine, CA 92618	(714) 790-0010
David J. Schwed	Romero Management Assoc	1805 West Avenue K	Lancaster, CA 93534	(805) 940-0540
Robert E. Gibeault	A-TEC	5515 River Avenue, # 301	Newport Beach, CA 92663	(714) 548-6836
Martyn C. Dodd	Gabel Dodd/EnergySoft, LLC	100 Galli Drive, # 1	Novato, CA 94949	(415) 883-5900
Robert Mowris, PE	Robert Mowris & Associates	10 Ridge Lane	Orinda, CA 94563	(925) 254-9770
Patrick Nkwocha, PE	Global Tech Services	3360 Foothill Blvd., #108	Pasadena, CA 91107	(626) 583-8205
James Trowbridge, PE	Trowbridge Engineering	8240 Caribbean Way	Sacramento, CA 95826	(916) 381-4753
Greg Cunningham	EnerSys Solutions LLC	114 Sansome St., #1201	San Francisco, CA 94104	(415) 296-9760
Charles Eley, T. Tathagat	Eley Associates	142 Minna Street	San Francisco, CA 94105	(415) 957-1977
John F. Kennedy, PE	GeoPraxis, Inc.	18850 Robinson Road	Sonoma, CA 95476	(707) 996-9408
Chandra Shinde, PE	ENVIRODESIGN GROUP	385 S. Lemon Ave., E-266	Walnut, CA 91789	(909) 598-1980
Colorado				
David A. Cohen	Architectural Energy Corp	2540 Frontier Ave, #201	Boulder, CO 80301	(303) 444-4149
Paul Reeves	PRC	140 South 34th Street	Boulder, CO 80303	(303) 499-8611
Ellen Franconi	P.O. Box 1284		Boulder, CO 80306	(303) 786-7319
Charles Fountain	Burns & McDonnell	8055 E. Tufts Avenue, #330	Denver, CO 80230	(303) 721-9292
Susan Reilly	Enermodal Engineering	1554 Emerson Street	Denver, CO 80218	(303) 861-2070
Donald E. Croy	Acrosoft/CAER Engineers	814 Eleventh Street	Golden, CO 80401	(303) 279-8136
Joel Neymark, PE	2140 Ellis Street		Golden, CO 80401	(303) 384-3672
Norm Weaver, PE	Interweaver Consulting	P.O. Box 775444	Steamboat Spgs, CO 80477	(970) 870-1710
Connecticut				
Adrian Tuluca	Steven Winter Associates	50 Washington Street	Norwalk, CT 06854	(203) 852-0110
District of Columbia				
Kurmit Rockwell, PE	XENERGY, Inc., Suite 1110	1025 Connecticut Ave., N.W.	Washington, DC 20036	(202) 872-1626
Florida				
Philip Wemhoff	1512 South McDuff Avenue		Jacksonville, FL 32205	(904) 632-7393
Dr. Paul Hutchins PE,CEM	Reynolds Smith & Hills, Inc.	4651 Salisbury Road	Jacksonville, FL 32256	(904) 279-2277

U. S. DOE-2 ENERGY CONSULTANTS (continued)

Georgia				
Lung-Sing Wong, PE	Building Performance Engrs.	1351 Oakbrook Dr., #100	Norcross, GA 30093	(770) 409-0400
Illinois				
Michael P. Doerr	Skidmore Owings Merrill	224 S Michigan Ave # 1000	Chicago, IL 60604	(312) 360-4623
Gary H. Michaels, PE	G.H. Michaels Associates	1512 Crain Street	Evanston, IL 60202	(847) 869-5859
Prem N. Mehrotra	General Energy Corp.	230 Madison Street	Oak Park, IL 60302	(708) 386-6000
Robert Henninger, PE	GARD Analytics, Inc.	1028 Busse Highway	Park Ridge, IL 60068-1802	(847) 698-5686
Kansas				
Dr. Brian A. Rock, PE	A/E Dept, Marvin Hall	University of Kansas	Lawrence, KS 66045-2222	(785) 864-3603
Massachusetts				
Michael Andelman	JRMA & Associates	421 Watertown St.	Boston, MA 02210	(617) 964-8889
C. Kalasinsky PE, T.Chan	R.G. Vanderweil Engrs., Inc.	274 Summer Street	Newton, MA 02458-1113	(617) 423-7423
Mark Mullins	DMI, Inc.	450 Lexington Street	Newton, MA 02466	(617) 527-1525
Missouri				
Mike Roberts	Roberts Engineering Co.	11946 Pennsylvania	Kansas City, MO 64145	(816) 942-8121
Bruce A. Leavitt, PE	Wm. Tao & Associates Inc.	2357-59th Street	St. Louis, MO 63110	(314) 644-1400
Montana				
Michael W Harrison, PE	Harrison Engineering	139 Bluebird Lane	Whitehall, Montana 59759	(406) 287-5370
New York				
J. Fireovid, K. Yousef	SAIC Energy Solutions Div.	1 Marcus Boulevard	Albany, NY 12205	(518) 458-2249
H. Henderson, S. Carlson	CDH Energy Corporation	P.O. Box 641	Cazenovia, NY 13035	(315)-655-1063
Dave Pruitt, Scott Frank	Jaros, Baum & Bolles	80 Pine Street	New York, NY	(212) 530-9300
North Carolina				
Hank Jackson, PE	P.O. Box 675		Weaverville, NC 28787-0675	(828) 658-0474
Gopal Shiddapur, PE	DukeSolutions (MC: ST05A)	230 S. Tryon Street, # 400	Charlotte, NC 28202	(704) 373-4439
Oregon				
J. Karasaki, PE, R. Ogle PE	CBG Consulting Engineers	6650 SW Redwood Ln, #355	Portland, OR 97224	(503) 620-3232
Texas				
Jeff S. Haberl	Energy Systems Laboratory	Texas A&M University	College Stn., TX 77843-3123	(409) 845-6065
Virginia				
Dave Walker	Walker Engineering	P.O. Box 366	Staffordsville, VA 24167	(540) 921-4544
Washington				
Steve Byrne	ITEM Systems, suite 344	321 High School Road NE	Bainbridge Island, WA 98110	(206) 855-9540
Gregory J. Banken, PE.	Q-Metrics, Inc.	P.O. Box 3016	Woodinville, WA 98072-3016	(425) 825-0200

WEATHER DATA SOURCES

BinMaker: The Weather Summary Tool (www.binmaker.com) From the Gas Research Institute, BinMaker is a CD-ROM based program that runs under Windows 95 or 3.1. It allows you to create summaries of U.S. hourly weather data (TMY2) then exports the results into spreadsheets or other analysis programs. Cost is $59.95 + $9.00 shipping (with a discount to GRI members).	Order No. GRI/98-0026 GRI Fulfillment Center 1510 Hubbard Drive Batavia, IL 60510 Phone: (773) 399-5414 / Fax (630) 406-5995 Email: Fillit@compuserve.com
DOE-2-Processed Versions of all TMY2 files for PC implementation (except CEARE)	ftp://anonymous:weather@gundog.lbl.gov/pub/ JJHTMY2.zip
Comprehensive collection of **TRY**, **TMY** and **CTZ** weather file libraries, from NCDC, which can be used on all PC versions of DOE-2. Includes original source data and pre-formatted packed versions on a single IBM format CD. Individual sites available.	Jennie Lathum or Martyn Dodd Gabel Dodd / EnergySoft, LLC 100 Galli Drive, Suite 1 Novato, CA 94949 Phone: (415) 883-5900 / Fax: (415) 883-5970
European Weather Files	Andre Dewint Alpha Pi, s.a. rue de Livourne 103/12 B-1050 BRUXELLES, Belgium Phone: 32-2-649-8359 / Fax: 32-2-649-9437
TMY data sets - download from the World Wide Web **TMY2** data sets and **TMY2 User Manual** - download from the World Wide Web [See *User News* Vol. 18, no. 2, p. 17]	TMY: http//oipea-www.rutgers.edu/ html_docs/TMY/tmy.html TMY2: http://rredc.nrel.gov/solar/
TMY (Typical Meteorological Year) **TRY** (Test Reference Year)	National Climatic Data Center 151 Patton Avenue, #120 Asheville, NC 28801 Phone: (704) 271-4871 order Fax 271-4876
CTZ (California Thermal Climate Zones)	California Energy Commission Bruce Maeda, MS-25 1516-9th Street Sacramento, CA 95814-5512 1-800-772-3300 Energy Hotline
WYEC (Weather Year for Energy Calculation)	ASHRAE 1791 Tullie Circle N.E. Atlanta, GA 30329 Phone: (404) 636-8400 / Fax: (404) 321-5478
Canadian Weather Files in WYEC2 Format	Dr. Didier Thevenard Numerical Logics, Inc. 119 University Avenue East, 3rd Floor Waterloo, ON N2J 2W1, Canada Phone: (519) 886-7820 / Fax: (519) 747-0881 www3.sympatico.ca/numlog numlog@sympatico.ca

* * * Featured Site This Issue * * *

World-Wide Web Sites for Building Energy Efficiency

The Leaking Electricity Home Page

eetd.lbl.gov/leaking

The energy used while an appliance is switched off or not performing its primary purpose is called **"standby consumption"** or **"leaking electricity."** A surprisingly large number of appliances -- from VCRs to dishwashers -- continue to consume electricity even after they have been switched off. Other appliances, such as cordless telephones, remote garage door openers, and battery chargers don't get switched off but draw power even when they are not performing their principal functions. This website presents information on leaking electricity and technologies to reduce it

For additional information about the Leaking Electricity Project at LBNL, please contact:

Alan Meier
Lawrence Berkeley National Laboratory
Building 90-2000
Berkeley, California 94720 USA
Tel: +1 (510) 486-4740
Fax: +1 (510) 486-4673
e-mail: AKMeier@LBL.gov

Televisions often leak electricity

The New Buildings Institute

www.newbuildings.org

The mission of **The New Buildings Institute**, incorporated as a non-profit in December, 1997, is to

- encourage the **efficient use of energy in buildings** to mitigate adverse environmental impacts
- support the **development of guidelines and standards** for improved building energy efficiency
- support the **implementation of energy-effective building codes** at the national and local levels
- **educate building officials, architects, engineers, contractors** and others responsible for the built environment in the methods and materials of building energy efficiency
- **promote long-term improvements in building design** and construction practices, and in the manufacture of building products

Douglas Mahone, Executive Director
11626 Fair Oaks Blvd., #302
Fair Oaks, CA 95628
Tel: (916) 966-9916
Fax: (916)962-0101

DOE-2.1E Documentation for International Users

(except Canada and Mexico)

The National Technical Information Service (NTIS) is the central resource for government-sponsored U.S. and world-wide scientific, technical, engineering, and business-related information. It is self-supporting and covers its operating expenses through product sales. NTIS has arrangements with cooperating organizations throughout the world to provide information on new and existing products and services, to process orders, resolve order-related problems, coordinate and accept payment in local currency, and clear orders through the local Customs office. If you live in a country that is not listed below, contact the agency nearest you. You may order by document name or order number (listed below).

Document Name	Order Number	Document Name	Order Number
DOE-2 Basics Manual (2.1E)	DE-940-13165	Reference Manual (2.1A)	LBL-8706, Rev.2
BDL Summary (2.1E)	DE-940-11217	Supplement (2.1E)	DE-940-11218
Sample Run Book (2.1E)	DE-940-11216	Engineers Manual (2.1A) [algorithm descriptions]	DE-830-04575

AUSTRALIA
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Correction

In Vol. 19, No. 1 (Spring 1998) of the *User News,* we printed an article entitled **"Underground Surfaces: How to Get a Better Underground Surface Heat Transfer Calculation in DOE-2.1E."**

Eagle-eyed Jim Trowbridge, a DOE-2 energy consultant, pointed out that one of the values in Table 2 was wrong. The PERIM-CONDUCT value for R-20 exterior concrete construction should be 0.65 Btu/hr-F-ft (1.12 W/m-K). We have reprinted the table below with the corrected value in the shaded cell. Sorry for the inconvenience.

Table 1: Perimeter Conduction Factors for Basement Walls*

Basement Wall		
Underground Wall Height	**Construction (see sketch for location of insulation)**	**PERIM-CONDUCT Btu/hr-F-ft (W/m-K)**
8 ft (deep basement)	R-0 (uninsulated), concrete	1.94 (3.35)
	4-ft R-5 exterior, concrete	1.28 (2.21)
	8-ft R-5 exterior, concrete	0.99 (1.71)
	4-ft R-10 exterior, concrete	1.15 (1.99)
	8-ft R-10 exterior, concrete	0.75 (1.30)
	8-ft R-15 exterior, concrete	0.63 (1.09)
	8-ft R-20 exterior, concrete	0.56(0.97)
	8-ft R-10 interior, concrete	0.78 (1.35)
	R-0, wood frame	1.30 (2.25)
	R-11, wood frame	0.88 (1.52)
	R-19, wood frame	0.79 (1.37)
	R-30, wood frame	0.66 (1.14)
4 ft (shallow basement)	R-0 (uninsulated), concrete	1.61 (2.78)
	R-5 exterior, concrete	0.89 (1.54)
	R-10 exterior, concrete	0.73 (1.26)
	R-15 exterior, concrete	0.66 (1.14)
	R-20 exterior, concrete	0.65 (1.12)
	R-10 interior, concrete	0.79 (1.37)
	R-0, wood frame	1.10 (1.90)
	R-11, wood frame	0.80 (1.38)
	R-19, wood frame	0.74 (1.28)

*Source: Y.J.Huang, L.S.Shen, J.C.Bull and L.F.Goldberg, "Whole-House Simulation of Foundation Heat Flows Using the DOE-2.1C Program," ASHRAE Trans. 94 (2), 1988, updated by Y.J. Huang, private communication.

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